Chapter 7: Status of Nonindigenous Species

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SUMMARY

Controlling invasive, nonindigenous species is cited as an important strategy and success indicator in the South Florida Water Management District's (District or SFWMD) Strategic Plan (SFWMD, 2010). Successfully managing invasive species also is tangentially key to many other strategic goals as invasive species have far-reaching effects—from evaluating environmental resource permits to managing Stormwater Treatment Areas (STAs) to restoring natural fire regimes. In support of collective activities of the many agencies involved in Everglades restoration, this chapter reviews the broad issues involving invasive, nonindigenous species in South Florida and their relationship to restoration, management, planning, organization, and funding. The report provides updates for priority invasive species, programmatic overviews of regional invasive species initiatives, and key issues linked to managing and preventing biological invasions in South Florida ecosystems.

While detailed information on many invasive species is not available, this document attempts to provide an update and annotations for priority plant and animal species, including summaries of new research findings. As part of continued efforts to streamline reporting, this year's update emphasizes new information obtained during Fiscal Year 2012 (FY2012) (October 1, 2011–September 30, 2012). During FY2012, the District spent roughly $18 million for overall invasive species prevention, control, and management in South Florida. More supporting information, including general background of the District's invasive species program and further detail on nonindigenous species, is also presented in Chapter 9 and Appendix 9-1 of the *2011 South Florida Environmental Report* (SFER) – *Volume I*.

In addition to providing the status of nonindigenous species programs and outlining programmatic needs, this document summarizes what, if any, control or management is under way for priority nonindigenous species considered to be capable of impacting the resources that the District is mandated to manage or restore.

Table 7-1 compiles the many invasive species management activities the District is engaged in and also serves to cross-reference region-specific coverage of invasive species issues of the STAs, Everglades, Lake Okeechobee, Kissimmee Basin, and coastal areas in other chapters of this volume (see Chapters 5, 6, 8, 9, and 10, respectively). Key FY2012 updates on South Florida's nonindigenous species highlighted in this chapter follow.

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NONINDIGENOUS PLANTS

- Sixty-nine species of nonindigenous plants are District priorities for control. Old World climbing fern, melaleuca, and Brazilian pepper continue to be systemwide priorities, while aquatic plants such as hydrilla, water hyacinth, and tropical American water grass are priorities in the Kissimmee Basin and Lake Okeechobee.
- Widespread efforts to control invasive plants are continuing. The District has the country's largest aquatic plant management program, managing floating and submerged aquatic vegetation systemwide. The agency's successful melaleuca management program has become a national model for regional, interagency invasive plant control programs. Melaleuca has been systematically cleared from Water Conservation Areas 2 and 3 and Lake Okeechobee and is now under maintenance control in these regions.
- Biological control of several invasive plants is showing promising results, with substantial reductions of melaleuca documented. The Comprehensive Everglades Restoration Plan's Melaleuca Eradication and Other Exotic Plants – Implement Biological Controls project continued to move forward. Construction of a mass rearing facility at the existing United States Department of Agriculture's Agricultural Research Service biological control laboratory in Davie, Florida will be completed by early 2013. The facility will support implementation of biological control rearing, field release, establishment, and field monitoring for melaleuca and other invasive nonindigenous species.

NONINDIGENOUS ANIMALS

- Considerable numbers of nonindigenous animals are known to occur in South Florida, ranging from approximately 55 species in the Kissimmee Basin to over 150 species in the Greater Everglades. Ranking animals for control is a serious challenge and prioritizing related threats across regulatory agencies is needed. The Florida Fish and Wildlife Conservation Commission continues to build its nonindigenous animal management program and coordinates closely with the District and other partners to manage nonnative animal species in South Florida. During 2012, federal, state, and tribal partners continued rapid response efforts to control newly discovered or expanding populations of northern African pythons, Nile monitors, and Argentine black and white tegus in the Greater Everglades.
- Burmese pythons continue to be observed and removed in the Everglades and surrounding rural areas, although in fewer numbers than last year. The District remains an active partner in regional efforts to halt the spread of this invasive reptile by conducting regional search and removal operations and supporting research for management related research.

The District continues to collaborate with the Everglades Cooperative Invasive Species Management Area, Lake Okeechobee Interagency Aquatic Plant Management Team, and South Florida Ecosystem Restoration Task Force. During 2012, these cross-jurisdictional teams facilitated development of region-wide invasive species monitoring programs, rapid response efforts, standardized data management, and outreach initiatives.

PROGRESS TOWARD MANAGEMENT AND CONTROL

The following section provides updates for FY2012 on control, research, monitoring, and coordination activities on invasive nonindigenous species that threaten the success of the District's mission.

INVASIVE PLANT MANAGEMENT

The District and other agencies continue to make significant progress toward achieving maintenance control of invasive, nonindigenous plant species on public conservation lands in South Florida. Large sections of the Greater Everglades and the marshes of Lake Okeechobee have reached or are nearing maintenance-control levels where melaleuca (*Melaleuca quinquenervia*) once dominated. Recent funding increases for invasive plant management in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) have resulted in substantial reductions in melaleuca infestations. However, remote sections of the southeastern area of Everglades National Park (ENP or Park) and the Refuge remain moderately to heavily impacted by difficult-to-control invasive plants. In these areas, the challenges of invasive plant control are immense due to inadequate financial resources and heavy infestations in difficult-to-access areas. It will likely be decades until these areas are successfully under control.

In **Table 7-1**, the District's FY2011 expenditures for nonindigenous plant control are summarized by land management regions. The purpose of this table is to report expenditures for the most abundant invasive plant species on District managed lands in support of the District's environmental restoration and flood control missions. In addition to these species, the District directs its staff and contractors to control all invasive plant species identified by the Florida Exotic Pest Plant Council (FLEPPC) as Category I species (FLEPPC, 2011). These species are documented to alter native plant communities by displacing native species, change community structures or ecological functions, or hybridize with native species. In FY2011, the District spent more than $19 million for overall invasive species prevention, control, and management in South Florida. In anticipation of continued budget shortfalls, the District reevaluated invasive plant management priorities to assure that gained ground is not lost. Experience has shown that vigilant reconnaissance and retreatment is necessary to maintain low levels of established invasive species. Biological controls are proving to be beneficial in this regard by reducing the rate of reestablishment for some species (Overholt et al., 2009; Rayamajhi et al., 2008). However, successful biological control programs are in place for only a handful of priority species so land managers must persist with frequent monitoring and control efforts.

Biological Control of Invasive Plant Species

Most nonindigenous species in Florida have limited or no predators, parasites, or pathogens. With few "natural enemies" in their new range, some nonindigenous species are able to grow larger, produce more offspring, spread quickly, and dramatically degrade Florida's sensitive habitats. The objective of classical biological control is to reunite host-specific natural enemies from the nonindigenous species' native range and introduce them into Florida to reestablish a balance in the regulation of the nonindigenous pest population.

Biological control research and implementation has yielded great successes in Florida but it is not a panacea. Detailed and lengthy studies are required to ensure that potential biological control agents will only attack the targeted invasive species and not native or agronomically important species. Biological control agents that are determined to be safe must pass through a lengthy review by state and federal regulatory agencies before they can be introduced. Despite these hurdles, biological control research and implementation has led to important advances in invasive plant management.

Table 7-1. Invasive plant species control expenditures by the South Florida Water Management District (District or SFWMD) in Fiscal Year 2011 (FY2011) (October 1, 2011–September 30, 2012), organized by land management region. (Note: Data will be provided in final version only.)

Priority Invasive Species	Upper Lakes	Kissimmee / Okeechobee	Lake Okeechobee	Everglades	East Coast	West Coast	Biocontrol	Total
Australian pine (*Casuarina equisetifolia*)								
Brazilian pepper (*Schinus terebinthifolius*)								
Cogongrass (*Imperata cylindrica*)								
Downy rose myrtle (*Rhodomyrtus tomentosa*)								
Hydrilla (*Hydrilla verticillata*)								
Melaleuca (*Melaleuca quinquenervia*)								
Old World climbing fern (*Lygodium microphyllum*)								
Shoebutton ardisia (*Ardisia elliptica*)								
Torpedograss (*Panicum repens*)								
Water hyacinth (*Eichhornia crassipes*)								
Water lettuce (*Pistia stratiotes*)								

Melaleuca

The melaleuca weevil (*Oxyops vitiosa*) was introduced in 1997 and established on melaleuca (*Melaleuca quinquenervia*) throughout the region. Feeding by the weevil reduces the tree's reproductive potential as much as 90 percent (Tipping et al., 2008), and the few trees that do reproduce have smaller flowers containing fewer seeds (Pratt et al., 2005; Rayamajhi et al., 2008). The melaleuca psyllid (*Boreioglycaspis melaleucae)* was released in 2002. Data indicates that feeding by psyllids induces leaf drop, eventually resulting in tree defoliation. United States Department of Agriculture (USDA) entomologists have determined that psyllid feeding on melaleuca seedlings results in 60 percent mortality in less than a year (Franks et al., 2006). The combined effect of feeding by the weevil and the psyllid has led to more than 80 percent stem mortality in some stands as well as decreases in melaleuca canopy cover over a 10-year period (1997–2007), resulting in a fourfold increase in plant species diversity following the introduction of biological control agents (Rayamajhi et al., 2009). A recently completed five-year field study found that melaleuca reinvasion was reduced by 97.8 percent compared to pre-biocontrol population densities despite a large fire that, in the past, would have promoted dense recruitment

of seedlings. The melaleuca midge (*Lophodiplosis trifida*) is the most recent biological control agent for melaleuca. The larvae feed on the internal structures of the stem, which damages the flow of nutrients to melaleuca buds and leaves. Feeding by the insect also causes the stems to produce galls that dramatically alter the morphology of melaleuca stems (**Figure 7-1**). Feeding damage by larvae can kill small individuals and, in concert with the other melaleuca biological control agents, provides increased control of the invasive tree.

Figure 7-1. The melaleuca midge (left) and melaleuca stem gall formation (right) resulting from feeding larvae (photos by United States Department of Agriculture Agricultural Research Service (USDA-ARS).

Water Hyacinth

Water hyacinth (*Eichhornia crassipes*) is an exotic floating plant that aggressively colonizes freshwater ecosystems in the southeastern and southwestern United States including the Everglades. Several biological control agents of water hyacinth introduced during the 1970s have reduced biomass by more than 50 percent and seed production by 90 percent, but additional agents are needed to reduce surface coverage. A new insect, the water hyacinth plant hopper (*Megamelus scutellaris*), was developed recently and released into the field in February 2010, making it the first new agent on water hyacinth in more than 30 years. To date, more than 40,000 individuals have been released at Stormwater Treatment Area 1 West (STA-1W) for establishment and evaluation. The species is cold tolerant and has overwintered as far north as Gainesville, Florida. A new population of this species from Paraguay that may be better adapted to higher summer temperatures has been obtained and should be deployed to field sites in Stormwater Treatment Area 1 East (STA-1E) and STA-1W in 2012. Another candidate insect, *Eccritotarus catarinensis*, has been imported into quarantine from Peru and is currently undergoing host range testing.

Air Potato

Liliocerus cheni, a leaf beetle from China that defoliates air potato (*Dioscorea bulbifera*) vines, was recently released in Broward County. Beetles were first released at Long Key (Broward) County Park in November 2011. This was set up only to determine their ability to survive after winter dieback of air potato, rather than in an attempt to establish a population. Sixteen of the original 150 beetles remained alive in March, despite a complete lack of foliage for at least three months. The remaining live beetles were released at the site and had established a thriving population by late June 2012. Additional releases have been made at Snyder Park (Fort Lauderdale city), Fern Forest County Park, and Pine Island Ridge Natural Area. We will continue to make periodic releases (weekly, if possibly) in order to establish field nurseries for redistribution throughout the region.

Old World Climbing Fern

The white lygodium moth (*Austromusotima camptozonale*) was the first agent to be released against Old World climbing fern (*Lygodium microphyllum*) in Florida. Releases of this insect began in 2004 and continued through 2007, with more than 40,000 individuals being mass reared and released, but no establishment was obtained. During 2011–2012, a second colonization effort with the moth was initiated using insects from a new lab colony. Approximately 18,000 larvae were distributed in series of open releases, but aside from sporadic recoveries of relatively low numbers of progeny, there was no evidence to indicate that populations were establishing in the field.

Figure 7-2. Damage to Old World climbing fern from larvae of the brown lygodium moth (photo by USDA-ARS).

The brown lygodium moth (*Neomusotima conspurcatalis*) was released in Florida in 2008 and rapidly established large field populations at release sites (Boughton and Pemberton, 2009) (**Figure 7-2**). At long-term study sites in Martin County, moth populations have successfully survived four winter seasons without additional insect releases.

The lygodium gall mite, *Floracarus perrepae*, induces leaf roll galls on the leaves of Old World climbing fern. The gall mite was released in 60 plots at five sites in South Florida during 2008 and 2009, and although the mite has marginally established and continues to be present at low numbers at some sites, rates of successful gall induction on field plants were much lower than anticipated.

Biocontrol Agents in Development

One additional biological control agent is awaiting a permit: *Neostromboceros albicomus*, a Thai sawfly that attacks Old World climbing fern. Release efforts are expected to be under way during 2012.

Everglades Invasive Plant Monitoring

To address the need for more detailed geospatial information on priority invasive plants and to meet requirements(Section 373.4592, Florida Statutes) to conduct biennial surveys of exotic species within the Everglades Protection Area (EPA), the District and the National Park Service (NPS) are now utilizing digital aerial sketch mapping (DASM) for regional invasive plant surveys. Sketch mapping is a remote sensing technique of observing ground conditions from low-flying aircraft and digitally mapping invasive plant infestations with GPS-linked touch screen computers. A detailed description of DASM methods is included in Chapter 6 of the 2011 SFER – Volume I.

This section documents results of invasive plant mapping DASM conducted by District and NPS biologists within the EPA between March 2010 and February 2012. Specifically, the spatial extent and dominance of four priority invasive plant species — Australian pine (*Casuarina* spp.), Brazilian pepper (*Schinus terebinthifolius*), melaleuca, and Old World climbing fern — were mapped. All management areas within the Everglades Cooperative Invasive Species Management Area (CISMA) were included in the survey. These include Holeyland, Rotenberger, and Southern Glades wildlife management areas, Big Cypress Seminole Indian Reservation, the Refuge, Everglades Wildlife Management Area [Water Conservation Areas 2 and 3 (WCA-2 and WCA-3, respectively)], the Miccosukee Reservation, Big Cypress National Preserve, ENP, East Coast

Buffer Lands, South Dade Wetlands, and other areas. Due to the size of the survey area (~2.8 million acres) and short sampling period when canopy species are maximally defoliated (January – March), surveys were conducted over three seasons.

Percent vegetation cover was estimated for each species polygon using a modified Braun-Blanquet cover abundance scale (Mueller-Dombois and Ellenberg, 1974): 1–5 percent, 6–25 percent, 26–51 percent, 51–75 percent, and greater than 75 percent. After completing Geographic Information System (GIS) quality assurance/quality control (QA/QC), infestation area and canopy area were calculated. Infested area is the summed area of all polygons for a given species. Canopy area is a percent cover-adjusted calculation for each species using the mid-point of each cover class [NIA = $\sum(.875)H_{dense} + \sum(.675)H_{high} + \sum(.375)H_{moderate} + \sum(.15)H_{low} + \sum(.025)H_{sparse}$, where H is area, in hectares, for a polygon in a given cover class]. To aid in visual interpretation of landscape-level spatial patterns of the polygon, vector data was transferred to a raster format and analyzed using a 1-kilometer grid system.

2010–2012 Sketch Mapping Results

Australian pine

Australian pine is the least abundant of the targeted species in the survey area with a total infestation area of 2,827 hectares (ha) [6,986 acres (ac)] (**Table 7-2**). This species is now at maintenance control levels in most areas of the Everglades, meaning that continuous low intensity management will keep this species at a low infestation level. The large majority of Australian pine (87 percent) occurs on District and Miami-Dade County lands in the South Dade Wetlands and Model Lands Basin (**Figure 7-3**), where it forms dense stands to widely scattered patches in remote mangrove swamps and sawgrass marsh. Australian pine also occurs in widely scattered patches in sawgrass marshes of northeastern ENP.

Table 7-2. Infested area and canopy area in hectares (ha) of four priority invasive plant species within the Everglades Cooperative Invasive Species Management Area (CISMA).

Species		Infested Area	Canopy Area
Common Name	Scientific Name	(ha)	(ha)
Brazilian pepper	*Schinus terebinthifolius*	30,477	7,733
Melaleuca	*Melaleuca quinquenervia*	18,228	6,377
Old World climbing fern	*Lygodium microphyllum*	7,057	1,415
Australian pine	*Casuarina equisetifolia*	2,827	389

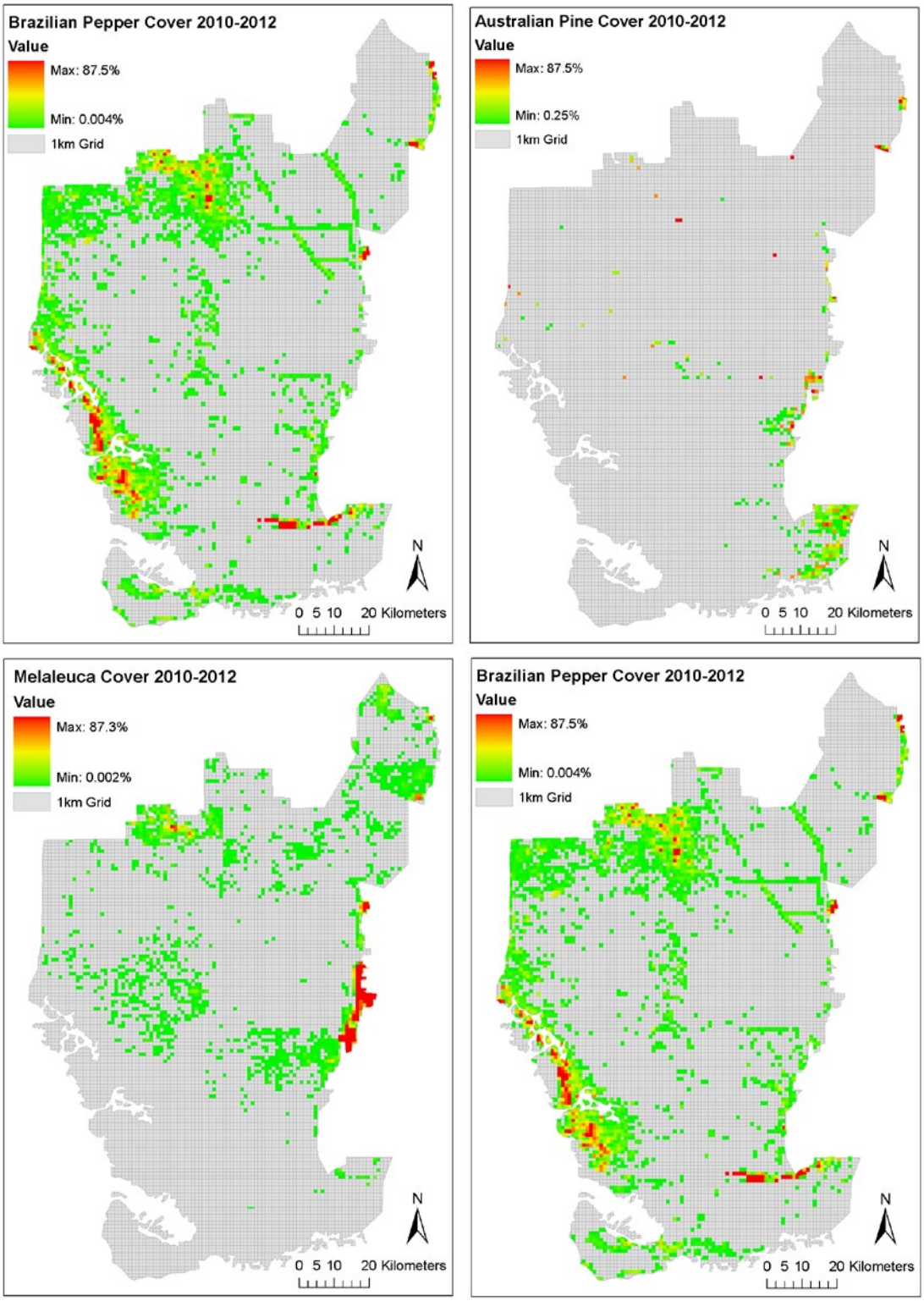

Figure 7-3. Distribution and cover of Brazilian pepper, Australian pine, melaleuca, and Old Word climbing fern in the Everglades. Values represent percent cover in a 1-kilometer grid.

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Brazilian pepper

Brazilian pepper is widely distributed throughout the survey area with an estimated infestation area of 30,477 ha (75,310 ac) (**Table 7-2**). Brazilian pepper is a dominant component of buttonwood swamps and graminoid (grass) marshes along the fringes of southwestern mangrove swamps of ENP. The most severe infestations extend from the Ten Thousand Islands Area to Cape Sable, representing roughly 60 percent of the total infestation area within the survey area (**Figure 7-3**). Dense infestations of Brazilian pepper also occur throughout the Big Cypress Seminole Indian Reservation, primarily on improved pastures and along the fringes of cypress swamps. Brazilian pepper was detected on small tree islands throughout the central Everglades region. In many cases, this species is dominant or co-dominant in the canopy. Ground-based observations of tree islands infested with Brazilian pepper revealed that little to no understory native vegetation remains beneath the canopy. Other widely scattered but dense infestations occur in the western Everglades hardwood hammocks within Big Cypress National Preserve. Brazilian pepper is rarely observed growing on the tree islands of the Refuge.

Melaleuca

Melaleuca occupies an estimated 18,228 ha (45,043 ac) within the survey area (**Table 7-2**). The most significant infestations occur in project and/or lease properties within the East Coast Buffer Lands, Big Cypress Seminole Indian Reservation, and northern sections of the Refuge (**Figure 7–3**). Melaleuca occurs in widely scattered small stands in sawgrass marsh and cypress swamps in Big Cypress National Preserve and eastern ENP. The exotic is at maintenance control levels in the Everglades Wildlife Management Area.

Old World Climbing Fern

Old World climbing fern is estimated to occupy 7,057 ha (17,431 ac) (infested area) within the survey area (**Table 7-2**). The large majority of Old World climbing fern (75 percent) mapped in this survey occurs within the Refuge, where it aggressively forms dense mats over tree island canopies (**Figure 7-3**). An estimated 1,988 ha of graminoid/prairie marsh in the southwestern sections of ENP are infested with Old World climbing fern. At the time of the survey (March 2010), Old World climbing fern cover was substantially reduced by frost damage in this region. It is expected that current estimates substantially underestimate infestation levels for both percent cover and areal extent. Old World climbing fern was not detected in WCA-3 using DASM. Ground-based observations of understory infestations in WCA-3 confirm that DASM is ineffective for early detection of this species in sub-canopy strata of tree islands. This result emphasizes the importance of continued ground-based surveys in helping to contain the spread of this aggressive Everglades invader.

INVASIVE ANIMAL MANAGEMENT

Efforts to develop control tools and management strategies for several priority species continued in FY2012. These include the Burmese python (*Python molurus bivittatus*) and other giant constrictors, the Nile monitor (*Varanus niloticus*), and the Argentine black and white tegu (*Tupinambis merianae*). Control tools are very limited for free-ranging reptiles, and the application of developed methods is often impracticable in sensitive environments where impacts to nontarget species are unacceptable. Available tools for removing reptiles generally include trapping, toxicants, barriers, dogs, and introduced predators (Witmer et al., 2007), as well as visual searching and pheromone attractants. Reed and Rodda (2009) provide a thorough review of primary and secondary control tools that may be considered for giant constrictors.

Regional invasive biologists associated with the Everglades CISMA have developed a conceptual response framework for established priority invasive animals in South Florida. Objectives within this framework are classified into three main categories — containment (slow the spread), eradicating incipient populations (remove outliers), and suppression (reduce impact in established areas) (Skip Snow, ENP, personal communication). The resources to implement this strategic framework remain insufficient, but close collaboration between agencies has allowed for some coordinated efforts. For example, multiple agencies are working together to conduct a rapid assessments of the Argentine black and white tegu to determine the status of tegus in South Florida, develop monitoring and control tools, and better understand the natural history of this invader in South Florida habitats. A significant step towards a more structured and coordinated framework would be the formation of a region-wide Early Detection Rapid Response (EDRR) strike team possibly modeled after the NPS's Exotic Plant Management Teams. In August 2012, an interagency python research and management team will meet to further develop recommendations for next steps in all components of python management.

There were a number of ongoing and new invasive animal initiatives during FY2012. These include ongoing monitoring and research efforts for Burmese python, northern African python (*Python sebae*), Argentine black and white tegu, Nile monitors, Gambian pouched rat (*Cricetomys gambianus*), and Cuban treefrog (*Osteopilus septentrionalis*), among others. Updates on these activities are briefly discussed in the *Invasive Species Status Updates* section in this volume. In addition, detailed summaries of two District-sponsored initiatives are provided below.

Everglades Invasive Reptile and Amphibian Monitoring Project

In 2010, the University of Florida (UF), Florida Fish and Wildlife Conservation Commission (FWC), and SFWMD began collaboration on the Everglades Invasive Reptile and Amphibian Monitoring Project. The purpose of the project is to develop a monitoring program for priority invasive reptiles and amphibians and their impacts to South Florida. Specifically, the program seeks to (1) determine the status and spread of existing populations and the occurrence of new populations of invasive reptiles and amphibians, (2) provide additional early detection and rapid response capability for removal of invasive reptiles and amphibians, and (3) evaluate the status and trends of populations in native reptiles, amphibians, and mammals. The monitoring program involves visual searches for targeted invasive species on fixed routes along levees and roads within the Refuge, Water Conservation Areas (WCAs), Big Cypress National Preserve, and ENP. Visual searches and call surveys, in addition to trapping, are conducted to monitor prey species. Thirteen routes have been established. The encounter rates for targeted invasive species ranged from 0.007 to 0.09 observations per kilometer. Brown anoles (*Anolis sagrei*), Cuban tree frogs, marine toads, feral cats (*Felis catus*), feral dogs (*Canis lupus familiaris*), and wild hogs (*Sus scrofa*) were the most commonly observed nonindigenous animal species (Frank Mazzotti, University of Florida, unpublished data). Opossums (*Didelphis virginiana*) and raccoons (*Proyon lotor*) were the most common native mammals observed. To date, eight Burmese pythons have been detected during these visual surveys. Moving forward, the team plans to expand routes, increase sampling frequency, and refine survey methods. In addition, the team has an occurrence experiment to evaluate whether the presence of invasive species is related to the absence of native species. In addition to fixed routes, the UF–FWC–SFWMD team has joined with Zoo Miami to provide early detection and rapid response capability for invasive reptiles in the Everglades CISMA. The EDRR surveys and trapping by this team have resulted in the removal of two Nile monitors, 88 Argentine black and white tegus, and 305 Oustalet's chameleons (*Furcifer oustaleti*).

Invasive Reptile Removal Permits

The FWC began its python removal program in 2009. Since its inception, 48 qualified individuals have been permitted to search for and remove Burmese pythons, as well as other specified nonnative snakes and lizards, on four FWC wildlife management areas. The purpose of the program is to provide data to scientists on the distribution, size, and gut contents of Burmese pythons, and help determine the extent of python range, which would assist stopping its spread in Florida.

In June 2011, the District executed a memorandum of agreement with the FWC establishing a modified permitting program that continues to be administered by the FWC. New permits are designed to make exotic reptile removal easier and more effective by opening additional land owned by the District, providing better access, and allowing use of a greater range of weapons, including guns, for the first time. Nine areas totaling more than 24,300 ha of District property are covered by new permits. This land lies between developed areas of Miami-Dade and Broward counties and Everglades restoration lands. Python populations in this crucial strip threaten both people and the ecological integrity of the Everglades. Agencies involved are confident the new program will significantly increase collection of python data and elimination of the snakes. Between January 1 and July 31, 2012, the expanded program yielded 35 pythons (either captured or found dead). Since the program's inception in 2009, 113 pythons have either been captured or found dead (Larry Connor, FWC, personal communication).

INTERAGENCY COORDINATION

This section provides updates on key interagency coordination activities pertaining to invasive, nonindigenous species in South Florida during FY2011. To be successful, regional management of nonindigenous species requires strategic integration of a broad spectrum of control measures across multiple jurisdictions. As such, numerous groups and agencies are necessarily involved with nonindigenous species management in Florida. More information on agency roles and responsibilities pertaining to nonindigenous species in Florida is available at www.elistore.org/reports_detail.asp?ID=11002&topic=Biodiversity_and_Invasive_Species.

Cooperative Invasive Species Management Areas

Florida has a long history of invasive species organizational cooperation including the FLEPPC, Noxious Exotic Weed Task Team, Florida Invasive Animal Task Team, and Invasive Species Working Group. At more local levels, land managers and invasive species scientists have informally coordinated “across the fence line” for many years. These regional groups recently began formalizing their partnerships into CISMAs to further enhance collaboration and coordination. CISMAs are local organizations, defined by a geographic boundary, that provide a mechanism for sharing invasive plant and animal management information and resources across jurisdictional boundaries to achieve regional invasive species prevention and control (MIPN, 2006). Based on the success of CISMAs in Florida and in western states, the Florida Invasive Species Partnership, formerly the Private Lands Incentive subcommittee of the Invasive Species Working Group, expanded its reach to act as a statewide umbrella organization for Florida CISMAs (www.floridainvasives.org). The Florida Invasive Species Partnership is an interagency collaboration, made up of federal, state, and local agencies, nongovernmental organizations and universities, focused on addressing the threat of invasive, nonnative species to Florida’s wildlife habitat, natural communities, and working agricultural and forest lands. The Florida Invasive Species Partnership serves Florida’s CISMAs by facilitating communication between existing CISMAs, fostering the development of new CISMAs, providing training for invasive species reporting, and providing access to existing online resources and efforts. To date there are 18 CISMAs in Florida covering roughly 93 percent of the state. Of these 18 CISMAs, seven occur

either wholly or partially within the Comprehensive Everglades Restoration Plan (CERP) footprint. Additional information on the Florida Invasive Species Partnership and the ongoing cooperative efforts throughout Florida can be found at www.floridainvasives.org/cismas.html.

Everglades CISMA

Invasive species scientists and Everglades land managers formed the Everglades CISMA in 2006 in order to improve cooperation and information exchange related to invasive species management. The Everglades CISMA partnership was formalized in 2008 with a memorandum of understanding among the District, United States Army Corps of Engineers (USACE), FWC, NPS, and United States Fish and Wildlife Service (USFWS). The memorandum of understanding recognizes the need for cooperation in the fight against invasive species and affirms the commitment of signatories to a common goal. Currently, the Everglades CISMA consists of 18 cooperators and partners, spanning the full spectrum of jurisdictions, including tribal, federal, state, local, and nongovernmental conservation organizations. The geographic extent of Everglades CISMA includes all state and federal conservation lands within the EPA, Miccosukee and Seminole lands, and Broward, Palm Beach, and Miami-Dade Counties (**Figure 7-4**).

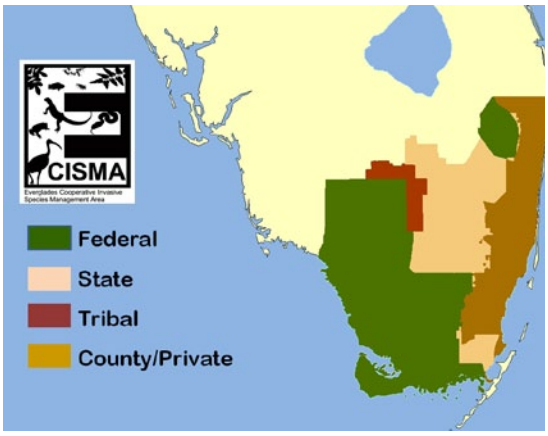

Figure 7-4. The Everglades Cooperative Invasive Species Management Area (CISMA).

Since its inception, the Everglades CISMA has achieved much progress towards improved coordination and cooperation among those engaged in invasive species management in the Everglades. These accomplishments include development of regional monitoring programs, standardization of data management, completion of numerous rapid response initiatives, and enhanced coordination of management and research activities.

During the last year, members of the Everglades CISMA worked together on a number of invasive species initiatives. In addition to continued coordination and collaboration on long-term management efforts for melaleuca, Old World climbing fern, Burmese pythons, and other widely established species, Everglades CISMA cooperators organized efforts to address recently discovered populations of nonindigenous plant and animal species. These include rapid assessment efforts to (1) determine the current status of tegu lizards and the recently discovered Oustalet's chameleon in the southeastern region of the Everglades, (2) rapid response efforts to control populations of mile-a-minute (*Mikania micrantha*), and (3) continued monitoring and treatment of the invasive mangrove species exotic black mangrove (also kripa) (*Lumnitzera racemosa*). Updates on these and other species are provided in this chapter.

The Everglades CISMA also coordinated and participated in a number of outreach initiatives aimed at increasing public awareness of invasive species. Everglades CISMA partners developed a number of outreach publications during 2012, including a pest alert for nonnative lizards in south Florida, a "Don't Let it Loose" bookmark, and an invasive species reporting application for smart phones. Everglades CISMA partners also participated in a number of outreach events including two pet amnesty day events. The group also hosted the Everglades Nonnative Fish Roundup aimed at increasing awareness of the issue of invasive freshwater fish.

In July 2012, Everglades CISMA partners convened for a two-day Everglades Invasive Species Summit in Broward County. Updates on invasive species management activities, new research, and outreach efforts were presented to attendees. As with previous summits, attendees worked in multiple breakout sessions to plan collaborative efforts and regional strategies for mutual invasive species priorities during the next year. Planned activities for 2013 include (1) numerous interagency work days focused on rapid response efforts for mile-a-minute, exotic black mangrove, northern African pythons, and Oustalet's chameleon; (2) continued monitoring and trapping efforts for Argentine black and white tegus and Nile monitors, and (3) several outreach and training initiatives aimed at increasing observations of priority species in the field (e.g., personnel for utility companies, Everglades biologists, law enforcement) and prevention education to the public.

Treasure Coast CISMA

In 2011, land managers, biologists and others along Florida's Treasure Coast held three steering committee meetings as participants in a regional partnership to cooperatively address the threats of invasive plants and animals. Since 2007, the Treasure Coast CISMA partnership extends from Indian River County south through St. Lucie, Martin, and northern Palm Beach counties and includes representatives and land managers from local, state, and federal governments. Groups involved include the SFWMD, Florida Park Service, Martin County, The Nature Conservancy, the Treasure Coast Resource Conservation and Development Council, Natural Resources Conservation Service, Palm Beach County Environmental Resources Management, USFWS, University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS), FWC, St. Lucie County, St. Lucie County Mosquito Control District, Aquatic Vegetation Control Inc., Habitat Specialists Inc., Florida Forest Service, Florida Grazing Land Coalition, Florida Native Plant Society, Indian River County, Palm Beach State College, and the Treasured Lands Foundation.

During this past year the Treasure Coast CISMA has continued its priority coastal control efforts on treating 293 acres of 10 linear shoreline miles targeting beach naupaka (*Scaevola taccada*) and other invasive species on public conservation lands. In addition, the CISMA treated beach naupaka on two private landowner's dunes and held several individual and general outreach efforts on this invasive species. Financial assistance for this project has been from the USFWS Coastal Program. The success of this partnership project was demonstrated by its receipt of the Coastal America Partnership Award for 2010.

During this past year the CISMA also held nine multi-agency cooperative invasive plant workdays on Florida Park Service, Martin County, Florida Power & Light's Barley Barbour Swamp, the Boy Scouts of America's Tanah Keeta Scout Reservation, LL Ranch, and other lands. The CISMA also updated the ranking of early detection rapid response invasive species and completed a field identification handout and presentation for the top ten species. The CISMA has also provided plant and animal invasive species outreach at the Palm Beach and Martin county fairs, NatureScape at MacArthur Beach State Park, FireFest at Jonathan Dickinson State Park, and through involvement with UF/IFAS educational programs and trainings in Martin and St. Lucie counties.

Other CISMAs

In addition to the Everglades and Treasure Coast CISMAs, there are five other CISMAs either wholly or partially within the footprint of the Greater Everglades ecosystem: Florida Keys Invasive Species Task Force, Southwest Florida CISMA, Heartland CISMA, Osceola County Cooperative Weed Management Area, and Central Florida CISMA. These CISMAs have also recognized many successes that have benefitted the Everglades ecosystem by furthering the concept of a landscape-level approach to invasive species management.

Lake Okeechobee Aquatic Plant Management Interagency Task Force

Invasive plant management on Lake Okeechobee is coordinated according to policy contained in a Lake Okeechobee Letter of Operating Procedures (1989) which was adopted by the involved agencies: USACE, SFWMD, Florida Department of Natural Resources, Florida Department of Environmental Protection, and FWC. At semi-monthly meetings, agency representatives plan treatment species and areas. Also, the group has flown semi-monthly since 1987 to estimate the lake's coverage of water lettuce (*Pistia stratiotes*) and water hyacinth. The group's considerations include accounting for the presence of endangered species, conservation of quality fish and wildlife habitat, and navigation. Public stakeholders and nongovernmental organizations are always encouraged to attend and provide input to this process. For more information, see http://www.floridainvasives.org/Okeechobee/index.html.

Kissimmee River and Chain of Lakes Coordination

Similar invasive plant treatment events are planned at interagency meetings for the Kissimmee River and Chain of Lakes, though these groups do not have a formal agreement such as the Letter of Operating Procedures for Lake Okeechobee. Funding from the Florida Aquatic Plant Management Trust Fund, administered by the FWC, is available for much of the work in these waters. The primary Kissimmee Chain of Lakes are given high state priority for large-scale aquatic plant management treatments, particularly for hydrilla (*Hydrilla verticillata*). The primary lakes are large (1,620–13,800 ha) and interconnected with flood protection canals, which are navigable with boat locks along the system.

INVASIVE SPECIES STATUS UPDATES

The following section, *Established and Emerging Species Priority Species* provides a summary of nonindigenous species that threaten the success of the District's mission. Eleven established plant species were selected by District staff based on potential and current implications to the District's infrastructure and ecological concerns. These species are presented with a "District-centric" justification for listing, and priority plant species may differ for other agencies, depending on regional factors and agency priorities and goals. The remaining ten established nonindigenous animal species presented in this section are in close alignment with the species identified by the Florida Invasive Animal Task Team (FIATT) as eradication, control, and research priorities for the state (see http://www.sfrestore.org/issueteams/fiatt/index.html for more information on FIATT). Omitting specific mention of other nonindigenous species in the following priority summaries does not imply that the species are not problematic or that control is not important. On the contrary, the need is urgent for distribution and biological data for many of these organisms.

Each of the 21 priority established species is listed in **Table 7-3** and summarized in a one-page synopsis that highlights key management issues and provides general distribution information. Additionally, each species synopsis includes an indicator-based stoplight table that gauges the status of the species in each of the District's land management regions, as well as Lake Okeechobee, Florida Bay, and the Florida Keys. These regions closely align with CERP's Restoration Coordination and Verification (RECOVER) modules, but are more inclusive of all conservation and project lands within the District boundary. The stoplight table technique was established through coordination among the Science Coordination Group, the Noxious Exotic Weed Task Team (NEWTT), and the FIATT of the South Florida Ecosystem Restoration Task Force (see Doren et al., 2009). Similar to its application in previous reports (e.g., 2010 SFER – Volume I, Chapter 9), the indicator table assesses each species by region according to the following questions: (1) how many acres within the module does this species occur in? (2) are the acres of the species in the module documented to be increasing, decreasing, or static? and (3) if

the species is decreasing in coverage, is it a direct result of an active biocontrol or chemical/mechanical control program? While the development of an assessment and monitoring program specifically designed for this purpose would be ideal, the exotic species indicator is currently constrained to data from existing monitoring and research programs. The table below provides a brief explanation of stoplight indicators provided for each priority species in the following species summaries.

Finally, updates are provided for six priority species that are currently the focus of rapid response efforts. For some of these species, agencies are currently directing resources toward monitoring and removal efforts with the stated objective of eradicating the species in Florida (e.g., Gambian pouched rat). For other species whose potential ecological impacts and population status are not sufficiently understood, response efforts are focused on rapid assessments to gather information necessary for informed decision making as to whether the species should be a priority for eradication attempts.

Table 7-3. The SFWMD's priority established species ranked by taxonomic group and then alphabetically by common name.

Plants		**Amphibians**	
Australian pine	*Casuarina equisetifolia*	Cuban treefrog	*Osteopilus septentrionalis*
Brazilian pepper	*Schinus terebinthifolius*		
Cogongrass	*Imperata cylindrica*		
Downy rosemyrtle	*Rhodomyrtus tomentosa*		
Hydrilla	*Hydrilla verticillata*		
Melaleuca	*Melaleuca quinquenervia*		
Old World climbing fern	*Lygodium microphyllum*		
Shoebutton ardisia	*Ardisia elliptica*		
Torpedograss	*Panicum repens*		
Water lettuce	*Pistia stratiotes*		
Water hyacinth	*Eichhornia crassipes*		
Mollusks		**Birds**	
Island apple snail	*Pomacea insularum*	Purple swamphen	*Porphyrio porphyrio*
Insects		**Reptiles**	
Mexican bromeliad weevil	*Metamasius callizona*	Argentine black and white tegu	*Tupinambis merianae*
Redbay ambrosia beetle	*Xyleborus glabratus*	Burmese python	*Python molurus bivittatus*
		Nile monitor	*Varanus niloticus*
Fishes		**Mammals**	
Asian swamp eel	*Monopterus albus*	Feral hog	*Sus scrofa*

ESTABLISHED AND EMERGING PRIORITY SPECIES

A one-page synopsis is provided on the following pages. for each established and emerging priority species listed in **Table 7-3**.

Australian Pine (*Casuarina* spp.)

SUMMARY: Three nonindigenous species in Florida are commonly and collectively referred to as Australian pine: *Casuarina equisetifolia*, *C. glauca*, and *C. cunninghamiana*. Australian pine is a fast-growing tree that readily colonizes rocky coasts, dunes, sandbars, islands, and inland habitats (Morton, 1980). This large tree produces a thick litter mat and compounds that inhibit growth of other plant species. These characteristics make Australian pine particularly destructive to native plant communities and can also interfere with sea turtle (**Figure 7-5**) and American crocodile nesting (Klukas, 1969). Mazzotti et al. (1981) found that small mammal populations are significantly lower in habitats dominated by Australian pine.

Figure 7-5. Australian pine can aggravate coastal erosion and reduce sea turtle nesting habitat (photo by the National Oceanic and Atmospheric Administration.

KEY MANAGEMENT ISSUES

Distribution (Figure 7-6): Australian pine is still common along District berms, within northeastern ENP, in the District's southern saline glades (C-111 basin), and Biscayne Bay National Park. Maintenance control is achieved throughout most of the EPA and most District-managed conservation lands (see *Everglades Invasive Plant Monitoring* in this chapter for more information). Status by management region is provided in **Table 7-4**.

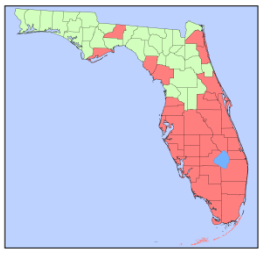

Figure 7-6. Distribution of Australian pine in Florida.

Control Tools: Herbicide controls are well established for this species. Recent research confirms hybridization of *Casuarina* species in Florida (Gaskin et al., 2009), which may present challenges for future biological control efforts.

Monitoring: Agencies monitor for this species in high priority public lands region-wide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands.

Interagency Coordination: Agency-sponsored control efforts are ongoing but are complicated by local and state initiatives to allow plantings of this genus in certain situations or prevent control of the species for aesthetic reasons. Such actions hinder agency abilities to control these species regionally.

Regulatory Tools: *Casuarina* species are designated as Florida Prohibited Aquatic Plants. *C. equisetifolia* and *C. glauca* are designated as Florida Noxious Weeds. There are no federal regulations regarding these species. Florida law allows plantings of *C. cunninghamiana* for windbreaks in commercial citrus groves.

Critical Needs: These include (1) state and local restrictions on planting and maintaining *Casuarina* species, and (2) state-wide private lands initiatives to reduce propagule pressure on conservation lands. Research into potential biological control agents is also needed.

Table 7-4. 2013 status of Australian pine by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

Brazilian Pepper (*Schinus terebinthifolius*)

SUMMARY: Brazilian pepper is an aggressive weed found throughout most of South and Central Florida (**Figure 7-7**). This shrub rapidly establishes in disturbed areas and then expands into adjacent natural areas (Cuda et al., 2006). Once established, Brazilian pepper severely reduces native plant and animal diversity (Workman, 1979; Curnutt, 1989) and alters fire regimes (Stevens and Beckage, 2009). The invasiveness of Brazilian pepper is partly explained by hybrid vigor. Florida's Brazilian pepper originated from multiple genetic strains (Mukherjee et al., 2012). The Florida hybrids were recently found to have greater fitness (germination rate, seedling survival) relative to their progenitors (Geiger et al., 2011).

Figure 7-7. Brazilian pepper invading a disturbed marsh (photo by the South Florida Water Management District (SFWMD).

KEY MANAGEMENT ISSUES

Distribution (Figure 7-8): Brazilian pepper is the most widespread and abundant nonindigenous species in the District (Ferriter and Pernas, 2005). This prolific seed producer is a dominant component of southwestern ENP and invades tree islands throughout the Greater Everglades region (see *Everglades Invasive Plant Monitoring* in this chapter for more information). Brazilian pepper also remains abundant on rights-of-way and adjacent private lands, facilitating constant reestablishment on conservation lands. Status by management area is provided in **Table 7-5**.

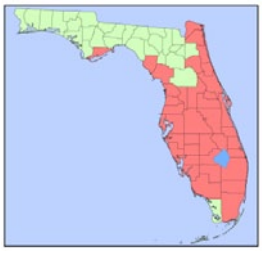

Figure 7-8. Distribution of Brazilian pepper in Florida.

Control Tools: Managers use herbicides and physical and mechanical controls. Wide distribution on private lands and rapid colonization via bird dispersal make it difficult to achieve sustained control in management areas. Some progress has been made in managing this species in more accessible areas, but many remote regions of the Everglades remain infested. Biological controls have been under development since 1993 but no effective agents have been released in the state. Due to budget reductions, the District will no longer fund research to identify control agents for this species.

Monitoring: Agencies monitor for this species in high priority public lands region-wide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands

Interagency Coordination: An interagency management plan was developed that called for the need for coordination but little progress has been made.

Regulatory Tools: Brazilian pepper is designated a Florida Noxious Weed and Florida Prohibited Aquatic Plant. There are no federal regulations regarding this species.

Critical Needs: These include (1) successes in biological control efforts, and (2) state-wide private lands initiatives to reduce propagule pressure on conservation lands.

Table 7-5. 2013 status of Brazilian pepper by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Cogongrass (*Imperata cylindrica*)

SUMMARY: Cogongrass is a fast-growing perennial grass native to southeastern Asia and is now among the top ten worst weeds internationally. Widely planted for forage in the early twentieth century, it is now estimated to infest 1,000,000 acres in Florida (Miller, 2007). Cogongrass aggressively invades pine flatwoods (**Figure 7-9**), disturbed sites, and marshes where it often displaces entire understory plant communities and alters ecosystem processes such as fire regimes (Lippincott, 2000) and biogeochemical cycling (Daneshgar and Jose, 2009; Holly et al., 2009).

Figure 7-9. Once established, cogongrass quickly dominates pineland understories (photo by the UGA).

KEY MANAGEMENT ISSUES

Distribution: Cogongrass is documented in natural areas throughout most of Florida (**Figure 7-10**). Within the District boundaries, cogongrass is most prevalent in the Kissimmee and Caloosahatchee watersheds, but in recent years it has spread in the Big Cypress National Preserve and in the DuPuis Management Area. Cogongrass has been estimated to infest about 6,900 acres in the District (SFWMD, 2008). Status by management region is provided in **Table 7-6**.

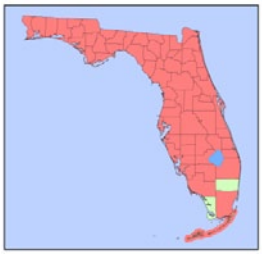

Figure 7-10. Distribution of cogongrass in Florida.

Control Tools: This species is difficult to control and requires judicious implementation of integrated controls. These include repeated herbicide applications in conjunction with prescribed fire, mechanical controls, and in some cases, native revegetation efforts. No biocontrol agents have been approved for release.

Monitoring: Agencies monitor for this species in high priority public lands region-wide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands.

Interagency Coordination: A strategy to address management of cogongrass throughout the southern United States was developed at the Regional Cogongrass Conference in 2007. The outcome of this meeting was a cogongrass management guide (Loewenstein and Miller) that provides guidance for control strategies, research priorities, and approaches to regional coordination.

Regulatory Tools: Cogongrass is designated as both a Federal and Florida Noxious Weed.

Critical Needs: Development of successful biological control agents would greatly improve regional control of this species. Additional coordination between governmental and private entities would be useful. Increased control efforts on linear utilities (e.g., railroads, power line corridors) are needed. A selective herbicide that would kill cogongrass but spare at least some native species would be very useful for working in natural areas. Fluazifop has some selective activity and should be investigated.

Table 7-6. 2013 status of cogongrass by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Downy Rose Myrtle (*Rhodomyrtus tomentosa*)

SUMMARY: Downy rose myrtle is an ornamental shrub of Asian origin. It now occurs in natural areas throughout South and Central Florida (**Figure 7-11**). This fast-growing shrub spreads prolifically into pine flatwoods and drained cypress strands, even in the absence of disturbance, and can form dense thickets that crowd out native vegetation. It is very fire-tolerant. Successful control of downy rose myrtle with herbicides is being accomplished where adequate resources are available. A substantial cost per acre to clear advanced invasions shows the value of detecting and eliminating downy rose myrtle before it dominates a natural area.

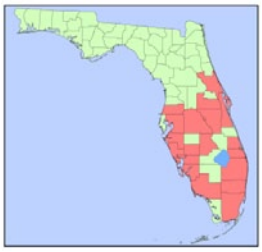

Figure 7-11. Distribution of downy rose myrtle in Florida.

KEY MANAGEMENT ISSUES

Distribution: Downy rose myrtle occurs throughout Central and South Florida, but the extent of heavy infestation is not well documented. Significant infestations are known to occur in coastal counties on the Atlantic and Gulf coasts. Status by management region is provided in **Table 7-7**.

Control Tools: This species is difficult to combat, but recent improvements in herbicide control show promise (**Figure 7-12**). A mix of glyphosate and imazapyr is effective, but kills native plants and inhibits revegetation. Dicamba provides good control of downy rose myrtle and spares many native flatwoods plants. This selectivity is an advantage for use in natural areas, although follow-up treatment is required. Tall dense growth of downy rose myrtle is hard to kill. Shredding with heavy equipment and treating regrowth is effective, but expensive. A candidate biological control agent has been imported into quarantine for testing and other insects are being evaluated overseas [Ted Center, United States Department of Agriculture Agricultural Research Service (USDA–ARS), personal communication].

Figure 7-12. Shredding and herbicides are used to control downy rose myrtle (photo by the SFWMD).

Monitoring: Because downy rose myrtle is difficult to detect from the air, monitoring is currently limited to observations by land managers. Predictive models are needed to identify ground-based monitoring priorities.

Interagency Coordination: The Treasure Coast Cooperative Invasive Species Management Area makes this species a priority for regional coordination.

Regulatory Tools: Downy rose myrtle is designated a Florida Noxious Weed.

Critical Needs: These include (1) feasibility studies for biological control, (2) statewide private lands initiatives to reduce propagule pressure on conservation lands, (3) plans to guide regional, integrated management, and (4) monitoring to support early detection and elimination.

Table 7-7. 2013 status of downy rosemyrtle by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Hydrilla (*Hydrilla verticillata*)

Figure 7-13. Dense hydrilla mats aggressively overtake native aquatic vegetation [photo by United States Department of Agriculture (USDA)].

SUMMARY: Hydrilla is a rooted submerged plant that can grow to the surface and form dense mats (**Figure 7-13**). It has a broad native distribution in the Old World and Indo-Pacific. Hydrilla was likely first introduced to Florida in the 1950s as an aquarium plant and has since spread throughout the state. Hydrilla overwhelms Florida's native aquatic plant communities, displacing valued native aquatic plants. This aggressive weed spreads to new waters mainly as fragments on boat trailers and boat parts. By the 1990s, hydrilla was widely distributed in the state, occupying more than 140,000 acres of public lakes and rivers.

KEY MANAGEMENT ISSUES

Distribution (Figure 7-14): Hydrilla is found in all types of water bodies in Florida. Since the 1980s, it has often dominated much of the Kissimmee Chain of Lakes. Hydrilla has been in Lake Okeechobee for about 20 years, but has not been a consistent problem. In some years, hydrilla has expanded rapidly to cover thousands of acres and required mechanical harvesting to open up boat trails. Status by management region is provided in **Table 7-8**.

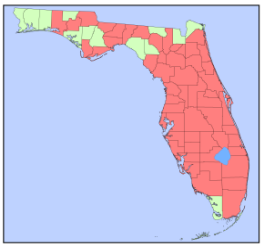

Figure 7-14. Distribution of hydrilla in Florida.

Control Tools: Hydrilla management has primarily depended on herbicide applications. This weed developed resistance to a commonly used systemic herbicide, so agencies now use a contact herbicide. Several new systemic herbicides are being evaluated. Several hydrilla biocontrol agents have been released in Florida, but none have exerted significant control. The United States Environmental Protection Agency (USEPA) has recently approved several other herbicides for aquatic use, with several more to come in the future. However, it will take years of laboratory and field research to determine if any of these newly approved herbicides control hydrilla on their own or when combined with other compounds.

Monitoring: The FWC monitors hydrilla throughout Florida's public waters and ranks these waters according to environmental and societal factors to prioritize funding distribution for treatment.

Interagency Coordination: The FWC coordinates management of hydrilla by allocating funds from the FWC Invasive Plant Management Control Trust Fund to local agencies for control.

Regulatory Tools: Hydrilla is listed as a Federal Noxious Weed and a Florida Prohibited Aquatic Plant.

Critical Needs: Continued research on effective systemic herbicides is needed. Decades of research have failed to produce a successful biological control agent for this species. However, this element of integrated management is needed for long-term control.

Table 7-8. 2013 status of hydrilla by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Melaleuca (*Melaleuca quinquenervia*)

Figure 7-15. A former sawgrass marsh now dominated by melaleuca (photo by the United States Fish and Wildlife Service).

SUMMARY: Before organized state and federal nonindigenous plant control operations were initiated in 1990, melaleuca (**Figure 7-15**) was widely distributed throughout the WCAs, ENP, Big Cypress National Preserve, Lake Okeechobee, and the Refuge. Overall, agency efforts to control melaleuca are succeeding in containing and reducing its spread. Still, melaleuca remains widely distributed on private lands throughout South and Central Florida, but the successful biological control program has reduced its rate of spread (Pratt et al., 2005). Melaleuca infests an estimated 273,000 acres of public and private lands within the District (SFWMD, 2008).

KEY MANAGEMENT ISSUES

Distribution (Figure 7-16): Melaleuca has been systematically cleared from Lake Okeechobee, WCA-2, WCA-3, and Big Cypress National Preserve. These areas are now under maintenance control, but melaleuca continues to reestablish in cleared areas. Land managers do report slower reinfestation rates as a result of biological control. Unfortunately, significant infestations still remain in the Refuge, eastern sections of the ENP, and the East Coast Buffer Lands. Status by management region is provided in **Table 7-9**.

Figure 7-16. Distribution of melaleuca in Florida.

Control Tools: The region's melaleuca management program is integrated. Herbicidal, mechanical, physical, and biological controls are all used. There are now three established biocontrol agents exerting substantial control on melaleuca (see *Biological Control of Invasive Plant Species* in this chapter).

Monitoring: Agencies monitor for this species in high priority public lands region-wide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands (see *Everglades Invasive Plant Monitoring* in this chapter for more information).

Interagency Coordination: Interagency coordination has proven successful for this species.

Regulatory Tools: Melaleuca is listed as a Federal Noxious Weed, a Florida Noxious Weed, and Florida Prohibited Aquatic Plant.

Critical Needs: Private lands initiatives to reduce remaining infestations adjacent to conservation lands are needed.

Table 7-9. 2013 status of melaleuca by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Old World Climbing Fern (*Lygodium microphyllum*)

SUMMARY: Perhaps no other plant species poses a greater threat to South Florida's mesic upland and wetland ecosystems than Old World climbing fern. This highly invasive fern smothers native vegetation, severely compromising plant species composition, destroying tree island canopy cover, and dominating understory communities (**Figure 7-17**). This species could potentially overtake most of South Florida's mesic and hydric forested plant communities (Gann et al., 1999; Lott et al., 2003; Volin et al., 2004).

Figure 7-17. Old World climbing fern overtaking a tree island in the Everglades (photo by the SFWMD).

KEY MANAGEMENT ISSUES

Distribution: Old World climbing fern dominates many tree islands, strand swamps, mesic to wet flatwoods, and other forested wetlands throughout South and Central Florida (**Figure 7-18**). First collected in Martin County, this species has now expanded as far north as Volusia County. Old World climbing fern infests an estimated 159,220 acres of public and private lands within the District (SFWMD, 2008). Status by management region is provided in **Table 7-10**.

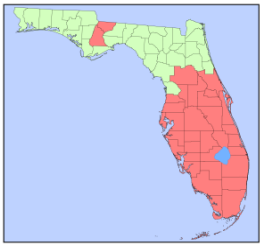

Figure 7-18. Distribution of Old World climbing fern in Florida.

Control Tools: Herbicides are used to control this species, but rapid reestablishment from abundant spores makes herbicide control costly and unlikely to succeed alone in regional control. Biological control is a critical component to effective long-term management of Old World climbing fern. Three agents have been released in Florida. One is becoming established, exhibiting localized reductions in the invasive fern (Boughton and Pemberton, 2009) (see *Biological Control of Invasive Plant Species* in this chapter).

Monitoring: Agencies monitor for this species in high priority public lands region-wide. DASM is conducted biennially within the Greater Everglades and on all District-owned lands (see *Everglades Invasive Plant Monitoring* in this chapter for more information).

Interagency Coordination: An interagency management plan was developed for this species and agencies are coordinating control and monitoring efforts.

Regulatory Tools: Old World climbing fern is listed as Federal and Florida Noxious Weed.

Critical Needs: These include (1) successes in biological control efforts, (2) ground-based monitoring programs, and (3) private lands initiatives to reduce propagule pressure on conservation lands.

Table 7-10. 2013 status of Old World climbing fern by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Shoebutton Ardisia (*Ardisia elliptica*)

SUMMARY: Shoebutton ardisia was imported as an ornamental shrub as early as 1900 (Gordon and Thomas, 1997). It aggressively invades understories of hammocks, tree islands, and disturbed wetlands. This species often forms single-species stands (**Figure 7-19**), resulting in local displacement of native plants. There is a tendency for reinvasion by shoebutton ardisia or other exotic plants following removal of dense thickets of this species. Early infestations may go unnoticed due to this species' physical similarity to the common native marlberry (*Ardisia escallonioides*).

Figure 7-19. Young shoebutton ardisia thicket in the southern Glades region (photo by the SFWMD).

KEY MANAGEMENT ISSUES

Distribution: Shoebutton is established in natural areas in southeastern Florida, particularly in the southern Glades and eastern portions of ENP (**Figure 7-20**). Status by management region is provided in **Table 7-11**.

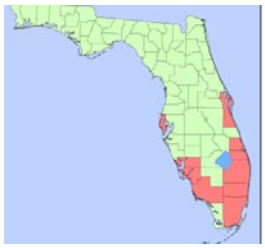

Figure 7-20. Distribution of shoebutton ardisia in Florida.

Control Tools: There are currently no biological controls or investigations into possible biological controls for this species. Individual plants or light infestations can be treated by cut stump herbicide application. This approach is prohibitively expensive for tall, dense thickets. The most efficient approach so far has been shredding with heavy equipment followed by herbicide application to stumps and soil or to regrowth. Several herbicides have been used with moderate success, and evaluations are being made. Over 100 acres of District land have been cleared of dense shoebutton ardisia and herbicide treated in the past four years. This land is now in various stages of restoration to native vegetation.

Monitoring: Shoebutton is difficult to detect from the air. Monitoring is currently limited to ground-based observations by land managers.

Interagency Coordination: While there is no region-wide strategic coordination for this species, biologists from the District, Miami-Dade County, and ENP are working closely to address major infestations in the southern Glades region.

Regulatory Tools: Shoebutton ardisia is listed as a Florida Noxious Weed.

Critical Needs: These include (1) increased funding to remove dense infestations in eastern Everglades region, (2) improved methods for revegetating southern glades marl soils with native vegetation after removal of shoebutton ardisia, and (3) monitoring to identify new populations.

Table 7-11. 2013 status of shoebutton ardisia by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

Torpedograss (*Panicum repens*)

SUMMARY: Torpedograss is an Old World grass originally introduced to Florida as a forage crop. This species forms dense, single-species stands (**Figure 7-21**) that easily outcompete native plants. Rhizomes, in which the plant accumulates significant energy reserves, make up the majority of this species' mass. These nutrient stores enable the plant to recover from disturbance events including fire, drought, herbicide application, and frost. Although no viable seed has been proven to have been produced in Florida, torpedograss readily spreads to new sites and within water bodies by vegetative means.

Figure 7-21. Torpedograss forms dense, impenetrable mats in littoral zones (photo by the SFWMD).

KEY MANAGEMENT ISSUES

Distribution: Torpedograss is ubiquitous in most regions of South Florida (**Figure 7-22**), but is most dominant in disturbed wetlands. More than 20,000 acres of torpedograss recently infested Lake Okeechobee's marshes. Treatments have reduced its coverage to an estimated 9,000 acres on the lake today (see Chapter 10 of this volume). Status by management region is provided in **Table 7-12**.

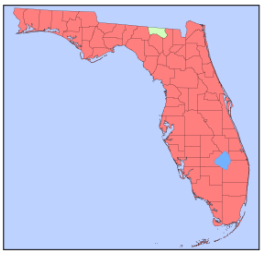

Figure 7-22. Distribution of torpedograss in Florida.

Control Tools: The District's initial control efforts on Lake Okeechobee aim to limit the plant's further expansion into new areas of the lake. Annually from 2003 to 2009, between 2,500 and 5,000 acres of torpedograss were treated in the lake's 100,000-acre marsh via aerial and ground herbicide application. Some treatments have provided years of control while others have been less effective. Ongoing evaluations aim to reduce this variability. Treatments on Lake Okeechobee are coordinated through the Lake Okeechobee Interagency Aquatic Plant Management Group and performed by the District with funding from the FWC Invasive Plant Management Control Trust Fund. Development of selective biological control of torpedograss is not likely to be successful because of the broad similarities of grass species. Numerous herbicides have recently received approval from EPA for use in aquatic sites. Some are expected to have activity on grasses, hopefully including torpedograss. Trials are planned for the immediate future.

Monitoring: The District and FWC have tracked the expansion of torpedograss in Lake Okeechobee since the 1980s. Outside of the lake, there is no systematic monitoring program for this species, and monitoring is limited to ground-based observations by land managers.

Regulatory Tools: There are no federal or state prohibitions for this species.

Critical Needs: Effective alternative treatments need to be developed to prevent possible induction of torpedograss resistance to the repeated applications of current herbicide mixture.

Table 7-12. 2013 status of torpedo grass by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

Water Lettuce (*Pistia stratiotes*)

Figure 7-23. Dense floating mat of water lettuce (photo by the SFWMD).

SUMMARY: Water lettuce is a floating aquatic plant native to South America, although it is now found throughout the tropics and subtropics (**Figure 7-23**). Rapid production of vegetative daughter plants occurs during all but the coolest months. New plants are also readily produced from seed and found to be up to 80 percent viable (Dray and Center, 1989). Water lettuce was reported by William Bartram in 1765 as forming dense mats on the St. Johns River. These mats continue to occur, clogging waterways and water management structures.

KEY MANAGEMENT ISSUES

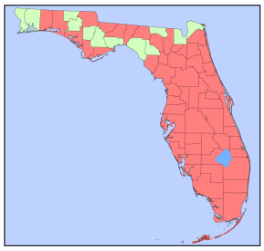

Figure 7-24. Distribution of water lettuce in Florida.

Distribution (Figure 7-24): Water lettuce inhabits all water body types in South Florida. Herbicide control efforts have virtually eliminated water lettuce from many canal systems, including urban Miami-Dade and Broward counties. However, most large lakes continue to harbor significant populations requiring frequent control. Also, on lakes in the Kissimmee chain and Lake Okeechobee water lettuce populations have expanded when treatments have ceased to accommodate snail kite foraging and nesting. When treatments can resume, treatment costs have increased since greater amounts of the plants are present. Status by management region is provided in **Table 7-13**.

Control Tools: Water lettuce is readily controlled by herbicides, but rapid reestablishment of this species in some water bodies necessitates frequent retreatments. Biocontrol agents for this species have been released in Florida, but none have significantly controlled the plant. Of these, the South American water lettuce weevil, *Neohydronymus affinis*, is widely established yet causes only numerous minute holes in the leaves of the plant.

Monitoring: The FWC monitors water lettuce in all public waters. The District routinely monitors its canals for large populations of this and other floating aquatic weeds.

Interagency Coordination: The FWC coordinates interagency management of water lettuce and other aquatic plants via solicitation of annual work plans from local public agencies and then allocates funds from the FWC Invasive Plant Management Control Trust Fund.

Regulatory Tools: Water lettuce is listed as a Florida Prohibited Aquatic Plant.

Critical Needs: Continued development of biological controls is needed to complement regional herbicide control programs.

Table 7-13. 2013 status of water lettuce by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Water Hyacinth (*Eichhornia crassipes*)

Figure 7-25. Dense floating mat of water hyacinth (photo by the SFWMD).

SUMMARY: Water hyacinth is a floating plant native to tropical South America (**Figure 7-25**). Introduced into Florida in 1884, the plant quickly filled miles of the St. Johns River, halting navigation and waterborne commerce. Daughter plants are produced vegetatively by budding and stolon production. Rapid production of daughter plants occurs during all but the coolest months. New plants are also readily produced from seed, which often germinate copiously on moist soils as water bodies refill following drawdowns. Water hyacinth reproductive capacities, adaptability, low nutritional requirements, and resistance to adverse environments make it impossible to eradicate and difficult to control.

KEY MANAGEMENT ISSUES

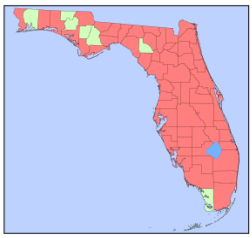

Figure 7-26. Distribution of water hyacinth in Florida.

Distribution (Figure 7-26): Water hyacinth inhabits all water body types in South Florida. Herbicide control efforts have virtually eliminated water hyacinth from many canal systems, including urban Miami-Dade and Broward counties. However, most large lakes continue to harbor significant populations requiring frequent control. On lakes in the Kissimmee chain and Lake Okeechobee, water hyacinth populations have expanded when treatments have ceased to accommodate snail kite foraging and nesting. When treatments can resume, treatment costs have increased since greater amounts of the plants are present. Status by management region is provided in **Table 7-14**.

Control Tools: Water hyacinth is readily controlled by herbicides, but rapid reestablishment of this species in some water bodies necessitates frequent retreatments. The USDA has released several water hyacinth biocontrol insects in Florida, including two weevils of the genus *Neochetina*. Despite reports of these weevils effectively limiting water hyacinth populations elsewhere in the world, no such decreases have occurred in Florida. In 2010, a new water hyacinth-feeding insect was released in Florida, the water hyacinth plant hopper (*Megamelus scutellaris*). USDA-ARS researchers found that this South American insect thoroughly controlled water hyacinths in quarantine lab trials. Whether it establishes in Florida and exerts any control on the plant remains to be seen.

Monitoring: The FWC monitors water hyacinth in all Florida public waters. The District routinely monitors its canals for large populations of this and other floating aquatic weeds.

Interagency Coordination: The FWC coordinates interagency management of water hyacinth and other aquatic plants via solicitation of annual work plans from local public agencies and then allocates funds from the FWC Invasive Plant Management Control Trust Fund.

Regulatory Tools: Water hyacinth is listed as a Florida Prohibited Aquatic Plant.

Critical Needs: Continued development of biological controls is needed.

Table 7-14. 2013 status of water hyacinth by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

Island Apple Snail (*Pomacea insularum*)

Figure 7-27. The large size of island apple snail may suppress prey consumption of juvenile snail kites [photo by the United States Geological Survey (USGS)].

SUMMARY: The island apple snail is a large (up to 10 centimeters), South American freshwater mollusk now established in Florida (**Figure 7-27**). Introduced globally through discards from aquaria and intentional releases as a food crop, this species is considered by the Global Invasive Species Database to be one of the 100 World's Worst Invasive Alien Species. Likely impacts in Florida include destruction of native aquatic vegetation and competition with native aquatic fauna. However, feeding trials have shown the snail exhibits a slight feeding preference for nonnative plants including torpedograss and hydrilla (Baker et al., 2010). The island apple snail may continue to spread and outcompete the native apple snail, *P. paludosa*, which is the primary food of the endangered Everglade snail kite (*Rostrhamus sociabilis*). Juvenile snail kites have difficulty handling mature island apple snails and experienced significantly lower net daily energy balances when feeding on nonindigenous snails (Cattau et al., 2010).

KEY MANAGEMENT ISSUES

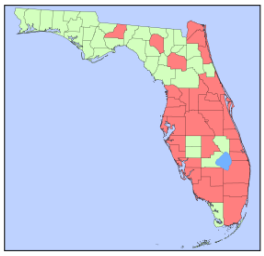

Figure 7-28. Distribution of island apple snails in Florida.

Distribution: The island apple snail has been reported widely throughout South Florida (**Figure 7-28**), typically in all types of water bodies including marshes, canals, lakes and rivers. ENP and Miccosukee Tribe monitoring results indicate that this species' abundance is increasing in many canals near or within the Everglades (e.g., Tamiami Trail Canal), and distributions may be expanding into open marsh habitats of ENP. Status by management region is provided in **Table 7-15**.

Control Tools: There are few control tools for this species with applicability in large natural areas. State and federal agencies need to dedicate resources to develop effective control strategies.

Monitoring: State and federal monitoring programs are either limited to focused geographic areas or participatory monitoring through outreach. State and federal agencies need to coordinate monitoring programs in support of a comprehensive management strategy.

Interagency Coordination: Limited interagency coordination has yielded little information and few attempts to understand this species' distribution, potential impacts, and possible control.

Regulatory Tools: This species is widely sold in the aquarium trade. Additional regulations are needed to curb the release of this and other nonnative *Pomacea* species while management efforts are under way.

Critical Needs: These include (1) development of control tools, (2) research to better understand impacts of this species, and (3) continued and expanded regional monitoring efforts.

Table 7-15. 2013 status of island apple snail by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

Mexican Bromeliad Weevil (*Metamasius callizona*)

SUMMARY: The Mexican bromeliad weevil was originally introduced to Florida via a shipment of bromeliads imported from Mexico. It was first detected in 1989, and is now found in many parts of South and Central Florida (Frank and Cave, 2005). Larvae of the weevil destroy bromeliads by mining into their stems (**Figure 7-29**). This damaging insect is documented to attack 12 native bromeliad species, 10 of which are state-listed as threatened or endangered, and one of which occurs naturally only in Florida. Two of these bromeliad species were listed due to damage done to their populations by the weevil. The bromeliads that are at risk are a prominent part of many south Florida woodlands from swamps to dry scrubs. Among the contributions of bromeliads to wildlife is that they catch rainwater, making is available to a variety of animals during dry periods.

Figure 7-29. A Tillandsia plant heavily damaged by larva of *M. callizona* (photo by the University of Florida).

KEY MANAGEMENT ISSUES

Distribution (Figure 7-30): The Mexican bromeliad weevil now infests bromeliads in the Sebastian, St. Lucie, Loxahatchee, Caloosahatchee, Peace, Myakka, and Manatee river systems as well as non-riverine sites. It is in Big Cypress National Preserve, Rookery Bay National Estuarine Preserve, the Refuge, Fakahatchee Strand Preserve State Park, Myakka River State Park, and several other state parks (Howard Frank, UF, personal communication). Status by management region is provided in **Table 7-16**.

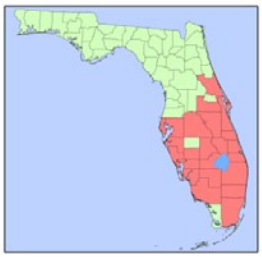

Figure 7-30. Distribution of Mexican bromeliad weevil in Florida.

Control Tools: The only practicable control tools for this species are biological control and prevention of new introductions. One agent, a parasitic fly (*Lixadmontia franki*), has been approved for release in the United States, but the insect has yet to become established. UF scientists continue to explore other potential biological control agents.

Monitoring: Regional monitoring of this species is limited to underfunded but determined efforts of university scientists engaged in biological control research.

Interagency Coordination: Interagency coordination is limited to the exchange of reporting information and some coordinated research.

Regulatory Tools: Federal screening needs improvement to prevent new introductions. Additionally, improved export screening is needed to prevent transport from Florida to other vulnerable regions (e.g., Puerto Rico).

Critical Needs: These include (1) development of biological controls, (2) continued monitoring of weevil spread and its effect on bromeliad populations, (3) conservation measures for impacted native bromeliad species, and (4) containment in Florida through effective export screening.

Table 7-16. 2013 status of Mexican bromeliad weevil by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

Laurel Wilt

SUMMARY: Laurel wilt is a lethal disease of red bay (*Persea borbonia*) and other members of the Laurel family (Lauraceae). The disease is caused by a fungus (*Raffaelea lauricola*) introduced into trees by the wood-boring redbay ambrosia beetle (*Xyleborus glabratus*) (FDACS, 2011). A native of Asia, the beetle was likely introduced into the United States via infested wood used for shipping crates (Harrington et al., 2011). Once infected, susceptible trees rapidly succumb to the pathogen and die (**Figure 7-31**). It also impacts other native and nonnative members of the Lauraceae family (Hanula et al., 2009) including swamp bay (*P. palustris*), an important species of many Everglades plant communities.

Figure 7-31. Dying red bay trees in a mixed hardwood forest (photo by the Florida Department of Agriculture and Consumer Services).

KEY MANAGEMENT ISSUES

Distribution (Figure 7-32): Since its arrive in 2002, the redbay ambrosia beetle and laurel wilt have spread quickly throughout the southeastern United States. In March 2010, the beetle was found in Miami-Dade County. Laurel wilt disease was subsequently confirmed on nearby swamp bay trees in February 2011. Aerial reconnaissance identified symptomatic swamp bay trees scattered throughout the Bird Drive Basin, northward into the Pennsuco Wetlands area, and westward into ENP. In February 2012, laurel wilt was also confirmed in the Refuge. Status by management region is provided in **Table 7-17**.

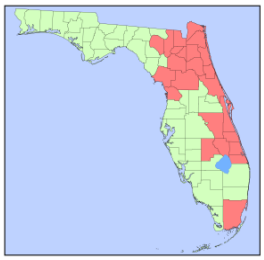

Figure 7-32. Distribution of the laurel wilt in Florida.

Control Tools: There is currently no feasible method for controlling this pest or associated disease in natural areas. A systemic fungicide (propiconazole) can protect individual trees for up to one year, but widespread utilization in natural areas is impractical (Mayfield et al., 2008).

Monitoring: State and federal agencies are monitoring the spread of laurel wilt disease and the redbay ambrosia beetle through the Cooperative Agricultural Pest Survey program. There is little to no research under way to assess the ecological impacts of laurel wilt disease.

Interagency Coordination: Interagency coordination is limited to the exchange of reporting information and some coordinated research.

Regulatory Tools: The redbay ambrosia beetle is considered a plant pest, so screening for additional introductions is carried out, but is inadequate.

Critical Needs: Critical research areas include (1) evaluating *Persea* resistance, (2) *Persea* seed/genetic conservation efforts, (3) potential chemical or biological control tools, (4) impacts on native plant communities, and (5) impacts on the Palamedes swallowtail butterfly (*Papilio palamedes*) and other host-specific commensals.

Table 7-17. 2013 Status of laurel wilt by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
		Not applicable				Not applicable	

Asian Swamp Eel (*Monopterus albus*)

SUMMARY: Swamp eels (**Figure 7-33**) are versatile animals, capable of living in extremely shallow water, traveling over land when necessary, and burrowing into mud to survive periods of drought. The eels are generalist predators with a voracious appetite for invertebrates, frogs, and fishes. Wild populations in Florida originated as escapes or releases associated with aquaculture, the pet trade, or live food markets. Regional biologists are concerned that this species may become widely established, since the diverse wetland habitats of the Greater Everglades may be suitable for the species. Additionally, Asian swamp eels have a broad salinity tolerance giving concern that this species could also establish populations in estuaries (Schofield and Nico, 2009).

Figure 7-33. Asian swamp eel (photo by the USGS).

KEY MANAGEMENT ISSUES

Distribution: During the late 1990s, three reproducing populations of Asian swamp eel were discovered in Florida in North Miami canals, canal networks near Homestead adjacent to ENP, and water bodies near Tampa [Fuller et al., 1999; L.G. Nico, United States Geological Survey (USGS), personal communication]. Unfortunately, recent monitoring efforts confirm the spread of this species into ENP from adjacent canal systems (Jeff Kline, ENP, personal communication). Status by management region is provided in **Table 7-18**.

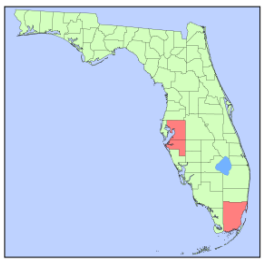

Figure 7-34. Distribution of swamp eels in Florida.

Control Tools: Given the abundance and wide distribution of swamp eels in Florida's canals, eradication is probably impossible; however, various control methods, such as electrofishing, are currently under investigation.

Monitoring: There is no regional, coordinated monitoring program for Asian swamp eels, but USFWS and NPS biologist conduct periodic surveys in the eastern Everglades region.

Interagency Coordination: No significant interagency coordination presently aims to manage this species.

Regulatory Tools: Currently, no regulations prohibit the importation or possession of this species in Florida.

Critical Needs: These include (1) research to better determine potential impacts and spread of this species, (2) research and development of control techniques, and (3) increased collaboration with CERP planners to integrate prevention measures for this and other aquatic invasive species in CERP-related projects.

Table 7-18. 2013 status of Asian swamp eel by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

Cuban Treefrog (*Osteopilus septentrionalis*)

Figure 7-35. The Cuban treefrog is now widely dispersed throughout Florida (photo by the USGS).

SUMMARY: The Cuban treefrog (**Figure 7-35**) is native to Cuba, the Cayman Islands, and the Bahamas. It was first reported in Florida in the 1920s, and was likely transported in cargo or ornamental plant shipments. Cuban treefrogs consume a variety of invertebrates and native treefrog species (Maskell et al., 2003). Native green and squirrel treefrogs (*Hyla cinerea* and *H. squirella*) are less likely to be found when Cuban treefrogs are present (Waddle et al., 2010), and when Cuban treefrogs are removed from an area, the abundance of native treefrogs increases (Rice et al., 2011). Given the Cuban treefrog's wide distribution and habitat tolerances, mounting evidence of direct impacts to native anuran species, and the lack of regional monitoring and control programs, the status of this species is red in all management regions.

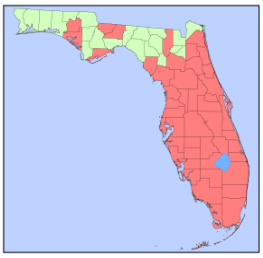

Figure 7-36. Distribution of Cuban treefrogs in Florida.

KEY MANAGEMENT ISSUES

Distribution: Cuban treefrogs inhabit natural and human-modified habitats throughout most of South and Central Florida (**Figure 7-36**). Natural habitats invaded by this species include pine forests, hardwood hammocks, and swamps. In urban and suburban settings, they are most commonly found on and around homes and buildings, and in gardens and landscape plants. They also occur in agricultural settings, orange groves, and plant nurseries (Johnson, 2007). Status by management region is provided in **Table 7-19**.

Control Tools: There are currently no agency-sponsored, coordinated control efforts for the Cuban treefrog in South Florida.

Monitoring: The UF and District are continuing a monitoring program for Cuban treefrogs and other priority invasive animals in the Everglades (see *Everglades Invasive Reptile and Amphibian Monitoring Project* update in this chapter). In addition, the UF/IFAS maintains a small monitoring and outreach program, but state and federal agencies need to assist with coordinating a state-wide monitoring and management program.

Interagency Coordination: No significant interagency coordination presently aims to manage this species.

Regulatory Tools: Currently, no regulations prohibit importation or possession of this species in Florida.

Critical Needs: Basic research on extent and severity of impacts to native species and development of control techniques are needed.

Table 7-19. 2013 status of the Cuban treefrog by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Purple Swamphen (*Porphyrio porphyrio*)

Figure 7-37. Purple swamphens are now well established in South Florida (photo by the SFWMD).

SUMMARY: The purple swamphen (**Figure 7-37**) is a rail native to Australia, Europe, Africa, and Asia. Its introduction was likely due to escapes from the Miami zoo and private aviculturists in Broward County. The purple swamphen feeds on shoots and reeds, invertebrates, small mollusks, fish, snakes, and the eggs and young of waterfowl (Pranty et al., 2000). Known to be highly aggressive and territorial, the purple swamphen could impact native water birds through competition for food and space and through direct predation. Rapid response efforts between 2006 and 2009 did not successfully reduce the abundance or distribution of this species. The management goal for this species has shifted from eradication to suppression (Jenny Eckles, FWC, personal communication).

KEY MANAGEMENT ISSUES

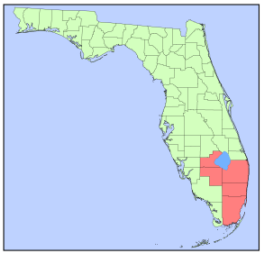

Figure 7-38. Distribution of purple swamphen in Florida.

Distribution: The original purple swamphen population in South Florida is believed to have established in Pembroke Pines in 1996 (S. Hardin, FWC, personal communication). In recent years, purple swamphens have been sighted in the WCAs, ENP, Big Cypress National Preserve, Lake Okeechobee, and in all Everglades STAs (**Figure 7-38**). Status by management region is provided in **Table 7-20**.

Control Tools: Previous efforts to remove birds by hunting did not significantly deplete the population. No other control tools are currently developed for this species. FWC is currently conducting prey and habitat analyses to inform a risk assessment, which will guide future management strategies (Jenny Ketterlin-Eckles, FWC, personal communication).

Monitoring: There are currently no coordinated monitoring efforts for this species.

Interagency Coordination: Local and state agencies have attempted to analyze this species' population and implement control. However, efforts to date have not halted the further spread of the species, and eradication is no longer considered feasible.

Regulatory Tools: Previous federal protection of this species under the Migratory Bird Treaty Act, which hindered control options, was removed by the USFWS in 2010. Federal and state regulations to restrict the possession of this species are needed to avoid future releases. There are currently no regulations that prohibit the importation or possession of this species in Florida.

Critical Needs: These include (1) additional monitoring to assess population expansion, (2) basic information on impacts of this species on native species, and (3) federal and state regulations to restrict possession of this species.

Table 7-20. 2013 status of purple swamphens by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Argentine Black and White Tegu (*Tupinambis merianae*)

SUMMARY: The Argentine black and white tegu is a large, omnivorous lizard filling a niche similar to that of the Nile monitor (**Figure 7-39**). In its native range, it prefers savannas and other open grassy areas and nests in burrows (Winck and Cechin, 2008). Two established populations are known in Florida — Hillsborough and Polk counties (Enge et al., 2006), and southern Miami-Dade County (Bob Reed, USGS, personal communication), both of which are suspected to have resulted from deliberate releases by pet dealers or breeders (Hardin, 2007). The spread of this species has the potential to impact Everglades restoration efforts by increasing predation on threatened and endangered species, including the American crocodile (*Crocodylus acutus*) and the Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) (Kevin Enge, FWC, unpublished data), as well as all other ground nesting birds and reptiles. Given the increasing likelihood that this species is expanding its range and that control tools are not completely developed, eradication from Florida may now be unachievable.

Figure 7-39. An Argentine black and white tegu near Everglades National Park (photo by the USGS).

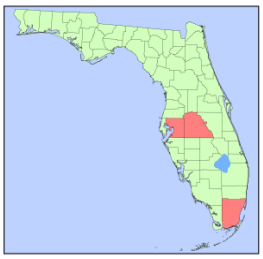

Figure 7-40. Distribution of Argentine black and white tegus in Florida.

KEY MANAGEMENT ISSUES

Distribution: Two established populations are known — Hillsborough and Polk counties (Enge et al., 2006), and southern Miami-Dade County (**Figure 7-40**). Data from monitoring efforts and reported sightings in the last year suggest that the South Florida population is expanding (Bob Reed, USGS, personal communication). Surveys conducted by the UF, Miami-Dade County, and the USGS resulted in the removal of 170 tegus between January 1 and July 18, 2012. This does not include a large number of unverified road kill reports. Status by management region is provided in **Table 7-21**.

Control Tools: Trapping may be an effective control method, but preliminary evaluations indicate that capture rates are low. Detection dogs may be effective for locating tegus, but there is currently no program to develop this tool.

Monitoring: Interagency members of the Everglades CISMA initiated monitoring, assessment, and control efforts in 2011. These efforts are ongoing.

Interagency Coordination: There is some interagency monitoring and trapping coordination. However, a fully funded rapid response team is needed if containment is to be achieved.

Regulatory Tools: This species should be considered for Conditional Reptile designation by the State of Florida.

Critical Needs: These include (1) dedicated funding for rapid response initiatives, (2) research on severity of impacts, and (3) federal and state regulations to restrict possession of this species.

Table 7-21. 2013 status of the Argentine black and white tegu by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
						Not applicable	

Burmese Python (*Python molurus bivittatus*)

SUMMARY: The Burmese python is now well established in South Florida. This large constrictor is a top predator known to prey upon more than 20 native Florida species (Snow et al., 2007), including the federally-endangered Key Largo wood rat (*Neotoma floridana smalli*) and wood stork (*Mycteria americana*). Control of this species is a top priority among agencies and policy makers. Record cold temperatures during January 2010 caused widespread mortality of Burmese pythons in South Florida (Mazzotti et al., 2010), leading to a 52 percent reduction in the number of Burmese pythons removed in 2011. A total of (to be provided in final version) Burmese pythons were removed between January and October 2012 (**Figure 7-41**).

Figure 7-41. Burmese pythons continue to be removed from the Everglades (photo by the SFWMD).

KEY MANAGEMENT ISSUES

Distribution: The Burmese python is found throughout the southern Everglades, particularly in ENP and adjacent lands (e.g., East Coast Buffer Lands, north ENP boundary along Tamiami Trail) (**Figure 7-42**). Status by management region is provided in **Table 7-22**.

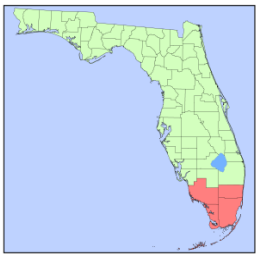

Figure 7-42. Distribution of Burmese pythons in Florida.

Control Tools: Control options for this species are limited. Reed and Rodda (2009) review control tools and their applicability to large constrictors in Florida. Potential controls include visual searching, traps, detection dogs, "Judas snakes," pheromone attractants, and toxicants. Research and development for many of these tools is ongoing.

Monitoring: A regional python monitoring network of agency staff, reptile enthusiasts, and other interested parties continues to develop and expand in South Florida.

Interagency Coordination: There is excellent interagency coordination for this species, but efforts to implement controls are constrained by limited resources and few control tools. An inter-research advisory panel convened in August 2012 to facilitate prioritization and coordination.

Regulatory Tools: The Burmese python is listed as a Conditional Reptile by the State of Florida. A federal ban on importation of this species was instated in January 2012.

Critical Needs: These include (1) Development of effective attractants for trapping, (2) technology to improve detection in the field, (3) implementation of detection dog program, (4) increased understanding of fine-scale movement patterns to improve search protocols, and (5) federal regulations to restrict possession of this species to limit new releases.

Table 7-22. 2013 status of the Burmese python by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys

Nile Monitor (*Varanus niloticus*)

Figure 7-43. Nile monitor at Homestead Air Force Base (photo by the Homestead Air Reserve Base).

SUMMARY: The Nile monitor is a large, predatory lizard (**Figure 7-43**) known for its intelligence and adaptability (Bennett, 1998). It is a generalist feeder (Losos and Greene, 1988) that commonly preys on crocodile eggs and hatchlings in Africa (Lenz, 2004). The impact of Nile monitors on Florida fauna is unknown, but their potential to eliminate or significantly reduce native species through competition and predation is high (Enge et al., 2004). In particular, wildlife biologists consider the Nile monitor to be a serious threat to gopher tortoises (*Gopherus polyphemus*), sea turtles, burrowing owls (*Athene* spp.), Florida gopher frogs (*Lithobates capito*), and other ground-nesting species (Meshaka, 2006; Hardin, 2007). The spread of this species into the Everglades has the potential to significantly impact restoration efforts. The Nile monitor has the potential to prey on threatened and endangered species and alter trophic dynamics by competing with native predators for habitat and food. Potentially affected RECOVER restoration performance measures include those for juvenile American crocodile and American alligator (*Alligator mississippiensis*) survival.

KEY MANAGEMENT ISSUES

Figure 7-44. Distribution of nile monitors in Florida.

Distribution: Established populations are documented in and around Cape Coral in Lee County (Enge et al., 2004), Homestead Air Force Base in Miami-Dade County, and the C-51 canal in central Palm Beach County (Jenny Ketterlin-Eckles, FWC, personal communication) (Figure 7-44). Numerous sightings have also been reported in suburban Broward County, approximately 1.5 miles from Water Conservation Area 3B (WCA-3B). Status by management region is provided in **Table 7-23**.

Control Tools: Snares, traps, and hunting are the only immediately available control tools for this species. Control efforts are piecemeal, consisting of citizen reporting programs (Cape Coral) and limited efforts by agency biologists involved with the Everglades CISMA Rapid Response Team.

Monitoring: The District and FWC are currently monitoring for, and when possible, removing Nile monitors in central Palm Beach County.

Interagency Coordination: Agency biologists are coordinating to some degree, but higher-level coordination to develop an interagency control program is needed.

Regulatory Tools: The Nile monitor is listed as a Conditional Reptile by the State of Florida. Federal importation regulations are needed to further curtail releases of this invasive species.

Critical Needs: Dedicated funding for aggressive control measures and federal regulations to restrict possession of this species to avoid additional releases are needed.

Table 7-23. 2013 status of the Nile monitor by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

Feral Hog (*Sus scrofa*)

SUMMARY: Feral hogs have existed on the Florida landscape since their introduction four centuries ago. Feral hogs consume a variety of vegetation, invertebrates, insects, reptiles, frogs, bird eggs, rodents, small mammals, and carrion (Laycock, 1966; Baber and Coblentz, 1987). This invasive mammal is also known to prey on sea turtles, gopher tortoises, and other at-risk wildlife (Singer, 2005). Rooting by feral hogs can negatively impact plant communities and may facilitate establishment of invasive plant species (Belden and Pelton, 1975; Duever et al., 1986). Although the ecological impacts of this species are apparent, proposals for aggressive hog control are controversial because they are a valued game species.

Figure 7-45. A pair of feral hogs at Lake Okeechobee [photo by the Florida Fish and Wildlife Conservation Commission (FWC)].

KEY MANAGEMENT ISSUES

Distribution: Wild hogs are reported in all 67 Florida counties (**Figure 7-46**). Within the District, feral hog populations are particularly high in the counties immediately north and west of Lake Okeechobee, and in the Big Cypress and East Coast Regions. Status by management region is provided in **Table 7-24**.

Figure 7-46. Distribution of feral hogs in Florida.

Control Tools: Hunting, trapping, and the use of toxicants may be used to control feral hogs. Feral hogs are considered legal game on public lands and may be hunted during designated seasons. On state lands managed for hunting by the FWC, hog hunting opportunities have been increased in recent years, which may better control populations. An aggressive new hog removal program has been implemented on some District lands. Under this program, contracts are awarded to selected individuals to remove hogs under flexible conditions.

Monitoring: There is no regional, coordinated monitoring program for the ubiquitous feral hog. Monitoring is limited to efforts associated with trapping programs and game management.

Interagency Coordination: Agencies coordinate control efforts to varying degrees at the local level. Scientists and land managers also exchange information related to control techniques. However, higher-level coordination is necessary to direct regional strategies for maintaining feral hog populations at the lowest feasible level.

Regulatory Tools: Existing feral hog management practices and policies for public conservation lands could be further revised with the aim of decreasing feral hog populations

Critical Needs: These include (1) development of target specific toxicants or contraceptives, (2) continuing updating of hunting regulations to maintain hunting pressure, and (3) initiatives for control on private lands.

Table 7-24. 2013 status of feral hogs by management region.

Upper Lakes	Kissimmee	Lake Okeechobee	East Coast Region	West Coast Region	Everglades	Florida Bay & Southern Estuaries	Florida Keys
							

SPECIES TARGETED FOR ERADIATION

Lumnitzera (Exotic Black Mangrove, Kripa)

Exotic black mangrove (also kripa) (*Lumnitzera racemosa*) is native to Asia but escaped from Fairchild Tropical Garden and was discovered to be rapidly proliferating in the vicinity of the garden in 2008. This plant aggressively competes with native mangrove species. Although there is no evidence concerning the effects of exotic black mangrove on Florida mangrove swamp diversity and function, the stakes are large. Contributions of mangroves to marine productivity and the economy of South Florida have been well documented (Hamilton and Snedaker, 1984). A response was launched almost immediately after invasion was detected. Several cooperative interagency workdays eliminated many of the invading plants, but this approach seemed inadequate for eradication.

During the last year, funding from the FWC supported a crew of three professional workers who removed 18,000 exotic black mangrove stems over four weeks, covering the entire known range of the introduction. The plants removed were almost entirely small seedlings coming up from the seed bank. Very few, if any, plants are producing seeds on the site. Because the infestation is apparently still restricted to a small area entirely accessible for control efforts, eradication of exotic black mangrove in Florida within a few years is possible. Consistent aggressive control work is crucial. If a major tropical storm or other mechanism spreads seeds to a wider area, opportunity for eradication may quickly be lost.

Mile-a-Minute

Mile-a-minute (*Mikania micrantha*) is an environmental and agricultural threat that has recently appeared in South Florida. This vine, which is native to parts of tropical and subtropical America, has turned into a disastrous weed where it was introduced to Asia, Australia, Africa, and other warm parts of the world (Holm et al., 1977; Zhang et al., 2004). This weed was discovered near Homestead in 2008, and an aggressive reconnaissance and eradication effort was begun immediately. Fighting the fast growing pest, however, is challenging. It roots freely from stems and small fragments can grow into new plants. Vast numbers of airborne seeds can spread the infestation. We are still not close to eradication.

Figure 7-47. A USDA biologist examines a large infestation of Mile-a-minute in rural Miami-Dade County (photo by FWC).

Major infestations exist in plant nurseries. The threat of quarantine is an incentive for nursery owners to eliminate the weed. Unfortunately, there are heavily infested abandoned nurseries. In many cases, contact with owners has not been possible. Infestations also exist on land associated with residences. Mile-a-minute twines among shrubbery and hedges. Herbicide treatment severely damages the ornamental plantings. Although most residents are cooperative, some are not and avoid contact (Dozier, 2012). Because of serious consequences if mile-a-minute becomes permanently established, strong eradication efforts will continue. Limited access to infested areas in conjunction with the weed's production of airborne seeds makes the outcome of these efforts uncertain.

Tropical American Watergrass

Tropical American watergrass (*Luziola subintegra*) was first discovered in North America in Lake Okeechobee in 2007. It immediately demonstrated very invasive and overwhelming growth. In 2009, the FLEPPC placed it in the most invasive plant category of its invasive plant list. This perennial South American aquatic grass grows floating or emergent with prostrate creeping culms, and forms stolons and floating mats.

District-sponsored research into seed dynamics of the plant found that the plant produces copious fertile seeds that remain viable for long periods under flooded conditions. Hundreds of seeds per plant are produced annually. Seed fertility quickly declines under non-flooded conditions. Upon maturity, seeds are immediately able to germinate. The plants decline in winter, apparently from combined effects of annual treatments and winter conditions. In spring and summer, plants grow from seed and from surviving rhizomes. Only by late summer are they tall enough for treatments to effectively contact the plants. Managers aim to treat the plants before the onset of annual flowering. During the reporting period, the District conducted herbicide applications over 139 ha to control tropical American watergrass in the western marsh region of Lake Okeechobee. Foraging and nesting of the endangered Everglade snail kite (*Rostrhamus sociabilis*) has led to establishment of human activity-free zones. Failure to treat in these zones has led to expansion of the plant in Lake Okeechobee.

Little likelihood exists for biological control to be a viable option for tropical American watergrass as discussed regarding grasses under torpedograss. As a grass in the rice tribe (Oryzeae), the importance of rice agriculture could further limit such investigations.

Gambian Pouched Rat

The Gambian pouch rat is a large, omnivorous rodent of African origin. Once popular in the exotic pet trade, the Centers for Disease Control banned their importation in 2003 because they are a carrier of monkey pox. Prior to this ban, numerous Gambian rats escaped captivity in the Florida Keys (Grassy Key) and established a reproducing population. This species is considered likely to invade the Florida mainland and is viewed as a significant threat to endangered rodents and other fauna, agriculture, and human health (Engeman et al., 2006). These concerns prompted agencies to initiate rapid response measures in 2005. Toxicant baits were effectively used to control large populations (Engeman et al., 2007). Control efforts for remaining animals involve baited traps. The rapid response efforts appeared to have been successful and, in 2009, FWC biologists cautiously declared that the population was eradicated while continuing periodic monitoring for the rodent. Then in 2011, the Gambian pouched rat was again found on Grassy Key. USDA and FWC biologists reinitiated trapping efforts in early 2011 and removed 28 rats over a ten-month period. FWC and USDA plan to continue trapping and monitoring efforts to the extent that funding and staffing resources allow. The rediscovery of this invasive species after it was presumed eradicated suggests that standards for eradication be reassessed for this species.

Figure 7-48. Gambian pouched rats continue to occur in the Florida Keys, despite years of trapping (photo by the USDA).

Northern African Python

Since 2002, 22 northern African pythons (*Python sebae*) have been found in the Bird Drive Basin in Miami-Dade County (Jenny Ketterlin-Eckles, FWC, personal communication), including multiple large adults, a pregnant female, and two hatchlings. This giant constrictor shares many natural history traits with the Burmese python and is considered a high risk for establishment and expansion throughout South Florida (Reed and Rodda, 2009). Rapid response efforts to delineate and eradicate this population are now of highest priority to local, state, and federal agencies. The District, Miccosukee Tribe of Indians, and Miami-Dade County, the primary land owners within the Bird Drive Basin, are working closely with the FWC and other agencies to address this emerging threat. The FWC, District, and other partnering agencies regularly deploy trained python surveyors to the area and have worked to remove artificial nesting habitat created from stockpiling cut melaleuca trees.

Between December 2011 and March 2012, FWC and Everglades CISMA partners organized three volunteer surveys in the Bird Drive Basin. No northern African pythons, skin sheds, or eggs were found in these searches. However, in November 2011, a FWC-permitted python hunter captured a 9-foot northern African python in the Bird Drive Basin. Then in January 2012, Miami-Dade County Fire and Rescue captured a 10-foot northern African python in a nearby neighborhood (Captain Jeffrey Fobb, Miami-Dade County, personal communication). The interagency team will continue to conduct northern African python surveys in this area with the objective of eradicating this species from South Florida natural areas.

As with the Burmese python, a special permit is now required to possess, import, sell, or breed the northern African python in Florida (Chapter 68-5.002 Florida Administrative Code). This permit is available only to licensed dealers, public exhibitors, or researchers that meet certain bio-security measures. Additionally, a federal ban on importation of this species was instated in January 2012.

Oustalet's Chameleon

A reproducing population of the Oustalet's chameleon (*Furcifer oustaleti*) was discovered in rural Miami-Dade County in early 2011. This large chameleon is native to Madagascar where it utilizes a wide variety of habitats, including human-altered environments (D'Cruze et al., 2007). The Florida population is believed to have established through intentional releases by reptile enthusiasts. An interagency team, led by the FWC, began a rapid assessment monitoring project in July 2011. Between July 2011 and May 2012, biologists removed 302 Oustalet's chameleons from a 122-ac site (Jenny Ketterlin Eckles, FWC, personal communication). Preliminary diet analysis indicates that this chameleon population consumes a variety of insect and anole species. The interagency team is continuing periodic surveys in the known population area in order to better understand the extent of the population and natural history of this species in Florida. Through these efforts biologists hope to determine the potential ecological impact of Oustalet's chameleon and whether the population is expanding without human assistance. This information will help scientists prioritize this species as candidate for eradication.

Figure 7-49. Oustalet's chameleon near Everglades National Park in Homestead Florida (photo by the FWC).

FUTURE NEEDS IN MANAGEMENT AND CONTROL

The elements of a comprehensive management program for some nonindigenous plant species — legislation, coordination, planning, research, education, training, and funding — have been in place in Florida for many years. The majority of plants identified in this chapter as priority species are being managed on public lands by local, state, or federal agencies. This is not true for most nonindigenous animal species. The threat of nonindigenous animals is becoming an important ecological and restoration issue for many agencies in Florida. Meaningful legislation to significantly limit new invasions, funding for control programs, and coordination at all levels are needed for a comprehensive nonindigenous animal management program for Florida. The number of nonindigenous animals is overwhelming, and agencies charged with managing natural systems have a responsibility to understand the distribution and impacts of these species and either initiate management operations or accept their occurrence and consequences in natural areas.

Given the documented impacts of nonindigenous organisms in South Florida, scientists are obliged to factor these species and their impacts into restoration models. Research is needed to understand the distribution, biology, and impacts of these nonindigenous organisms. Controlling and managing nonindigenous organisms in an all-taxa approach is a new idea, even among ecologists, but it is sure to emerge as an important field of science given global trade and the virtual "open barn" situation. Organisms will continue arriving and establishing breeding populations in new environments, especially in South Florida.

Regardless of taxa, the process of biological invasion — from introduction to establishment to ecosystem engineer — is complex, involves many environmental factors, and may take many decades to complete. Relatively few nonindigenous species become invasive in their new environments, but a very few species can wreak major economic and ecologic havoc. Species that appear benign for many years or even decades may suddenly spread rapidly following floods, fires, droughts, hurricanes, long-term commercial availability, or other factors. Resource managers must recognize these species during the early, incipient phase to maximize the potential for containing or eradicating them. As part of this effort, an applied monitoring program and a tracking system for nonindigenous plant and animal species are needed before their introduction.

Species like the purple swamphen in the Everglades and Gambian pouched rat in the Florida Keys illustrate the need for agencies to act quickly to contain and attempt to eradicate animals that have the potential to become widespread and difficult to control. While definitive research is lacking to support the immediate management of these particular species, it is widely accepted in the invasive species literature that catching a species in its incipient phase is advantageous, even where research may be inadequate or lacking. This is one of the most important reasons to develop a biological risk assessment "tool box" for nonindigenous species to help discern which species are most likely to become invasive both prior to introduction and during the earliest phases of their establishment when eradication is most feasible.

The use of an EDRR program increases the likelihood that invasions will be controlled while the species is still localized and population levels are so low that eradication is possible (National Invasive Species Council, 2003). Once populations of an invasive species are widely established, eradication becomes virtually impossible and perpetual control is the only option. Implementing an EDRR program is also typically much less expensive than a long-term management program. Given the risks associated with waiting for research and long-term monitoring to catch up, some agencies have opted to initiate control programs concurrently with biological or ecological research programs. Prompt cooperative action to eliminate emerging populations of sacred ibis (*Threskiornis aethiopicus)* and the invasive mangrove species *Lumnitzera racemosa* have been successful. These EDRR efforts may have prevented widespread ecological harm by these new invaders and also saved significant public resources required to manage more widespread

invasions. Biological risk assessments are being developed to enable agencies to determine which species are most likely to become problems (Gordon et al., 2006; Simons and De Poorter, 2009). Many states struggle with how to implement an EDRR approach because awareness and funding often lag, preventing a real rapid response. For South Florida, groups such as the Everglades CISMA are attempting to initiate additional EDRR efforts.

An overarching theme in this chapter is describing the alarming extent and impacts of some nonindigenous species and stating the need for increased coordination and control. While these observations are valid, control efforts against certain nonindigenous species have proven successful and demonstrate that effective management is possible with effective interagency support and adequate funding. For instance, melaleuca once was thought to be unmanageable in the state because it was so widespread and difficult to control. The District-led melaleuca management program is entering its twentieth year. Resource management agencies estimate this program has cost nearly $41 million to date. However, melaleuca is now under maintenance control on Lake Okeechobee and in the majority of the Everglades and Florida's melaleuca management program is a model for invasive species management nationally. The success of this program is largely attributed to integrated management approaches, sustained funding, and close interagency coordination, all of which foster information and technology transfer, regional strategic planning, increased financial efficiency, and improved public awareness.

For the nonindigenous species that are already widely established, long-term commitments to integrated control programs are the only feasible means of containing and reversing impacts. Effective management of other entrenched and difficult-to-control species, such as Old World climbing fern and the Burmese python, will require sustained resource allocation for development and implementation of control programs, similar to that used for the management of melaleuca, if Everglades restoration is to be successful. Further, many biological invasions are likely to be permanent and may easily reestablish dominance if maintenance and control management is not sustained. For this reason, preventing importation of potentially invasive species through improved regulatory programs and regional monitoring programs should be a priority focus of policy makers, regulators, scientists, and land managers moving forward.

ACKNOWLEDGMENTS

This chapter was produced with the help of several individuals who contributed their time and knowledge to the content and format of this document. The authors wish to thank Skip Snow (ENP), Jenny Ketterlin-Eckles (FWC), Jennifer Leads (SFWMD), Tony Pernas (ENP), Jon Lane (USACE), and many others for their assistance with this chapter.

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